

JOHN F. KENNEDY SPACE CENTER

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TAIL SERVICE MAST DESIGN REPORT

SATURN V GROUND SUPPORT EQUIPMENT LAUNCH COMPLEX 39

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CORRECTIONS TO TM-23-0-D

- Page 1-2

 lest line "Eigure 1-2" should read figure 1-3
- Page 3-22

 line 13- "scyncronization" should be synchronization
- Page 3-28 \\ lines 7, 16, 20 "Fail" should be Tail
- Page 4-9 figure inverted
- Page 7-1 7-2 C1 200 psi should read 2000 psi
- Page 8-18
 last two columns should be a (red/sec) and a (red/sec2)
- Page 8-25
 first two equations 3.982 cos should be 3.982 cos 3.982 sin should be 3.982 sin 3
- Page 8-27 last column Mr² should be Mr².
- Page 3-34
 equation 8-8 (P_r P_a) should be (P_r P_s)
- Page 8-35 equation 8-10 $\frac{1}{2}Q^2$ $(1/A_r^2 1/A_r^2)$ term should be $\frac{1}{2}Q^2\rho(1/A_r^2 1/A_r^2)$
- Page 8-46 line 17 "acceleration y = 6" should be acceleration y = 0
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KENNEDY SPACE CENTER

TM-23-0-D

TAIL SERVICE MAST DESIGN REPORT

LAUNCH COMPLEX 39

GROUND SUPPORT EQUIPMENT

ABSTRACT

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This preliminary design handbook contains information covering the overall design, function, and engineering of the Tail Service Mast. Information pertaining to schedules, location, and testing of the prototype is presented. A design analysis section is included deriving the feasibility of the Tail Service Mast.

TM-23-0-D

INTERNAL TECHNICAL REPORT

DESIGN, TESTING, AND OPERATION MANUAL

TAIL SERVICE MAST

COMPLEX 39 - GROUND SUPPORT EQUIPMENT

__ N O T I C E __

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LAUNCH SUPPORT EQUIPMENT ENGINEERING DIVISION
HUNTSVILLE, ALABAMA

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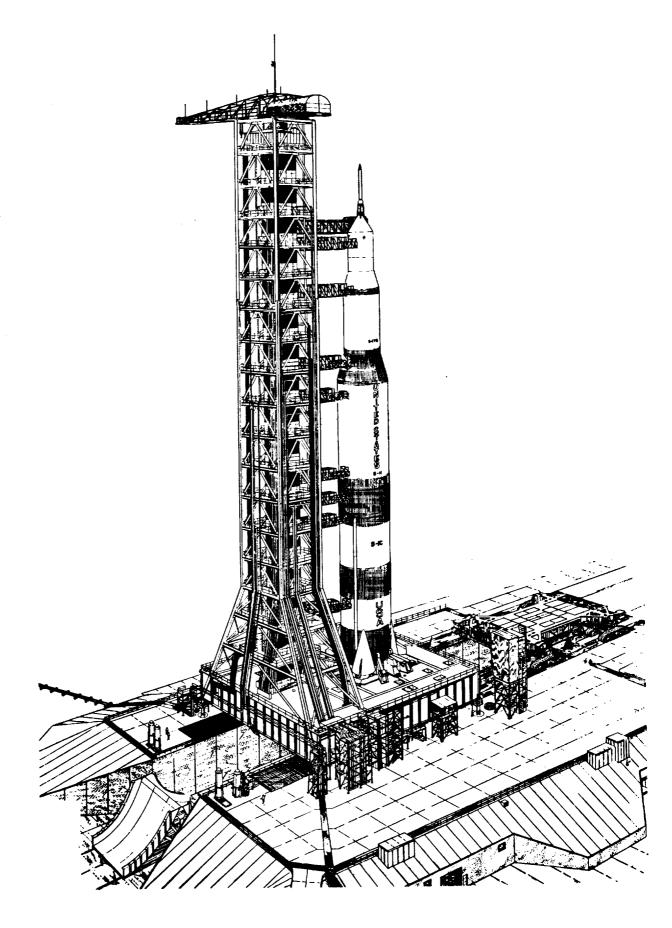


Fig. 1-1 Launch Umbilical Tower

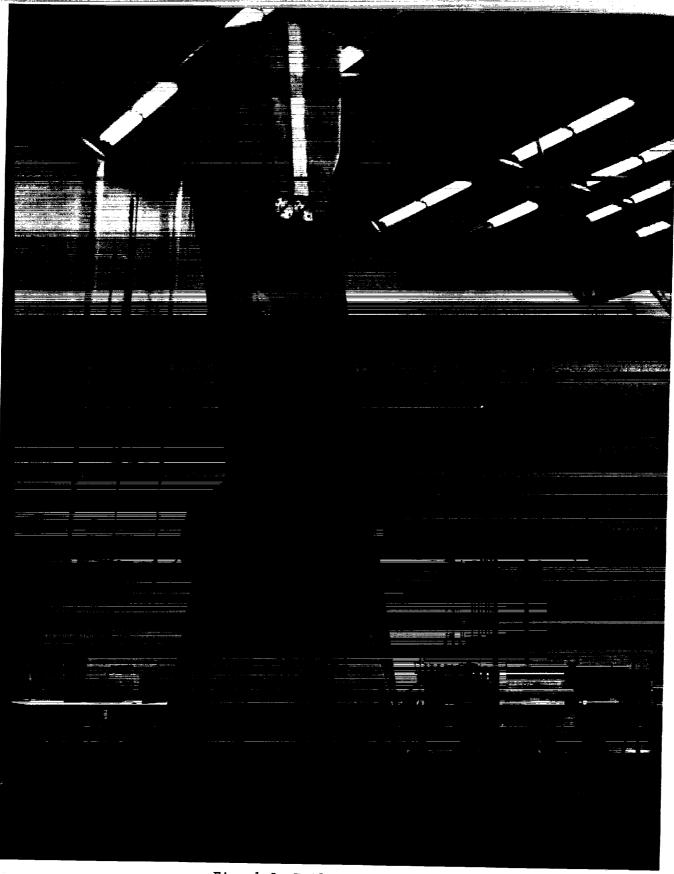


Fig. 1-2 Tail Service Mast

SECTION I

I-I PURPOSE I-2 SCOPE I-3 GENERAL

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SECTION I INTRODUCTION ;

1-1 PURPOSE

The objective of this report is to present the latest design information to those persons concerned with Launch Complex 39 pertaining to the Tail Service Mast area. This report will provide pertinent information relating to the testing of the prototype Tail Service Mast. Complete design information has been presented as a guide to facilitate maintenance and location of malfunctions.

1-2 SCOPE

This document describes the design, operation, function, and test procedure of the Tail Service Mast. Final design will be dependent upon performance of the prototype structure. A design analysis section is included which gives operating parameters and a stress analysis of the structure in detail. A stress analysis of the new fiberglass hood was not received in time to be included in this preliminary report.

1-3 GENERAL

i i

A Tail Service Mast prototype was built and delivered to the Test Division at Huntsville, Alabama. The prototype was complete with pneumatic, electrical and hydraulic components installed. All service lines were terminated with fittings for connection to the ground-half of the umbilical attachment.

Test Division will install the umbilical carrier assembly, connect the service lines, and install the prototype mast for test purposes. Test procedures are outlined and location of transducers for test data is indicated.

Upon completion of all tests the test results will be correlated with the design of the Tail Service Mast and a final design handbook will be completed.

The Tail Service Masts are designated by numbers in relation to their location between the hold-down arms of the booster.

- a. Mast number 1-2 is located between hold-down arms I and II and is nearest hold-down arm number I.
- b. Mast number 3-2 is located between hold-down arms II and III and is nearest hold-down arm number III.
- c. Mast number 3-4 is located between hold-down arms III and IV and is nearest hold-down arm number III.

Locations of the Tail Service Masts relative to the Launch Umbilical Tower and deck are shown in figure 1-2.

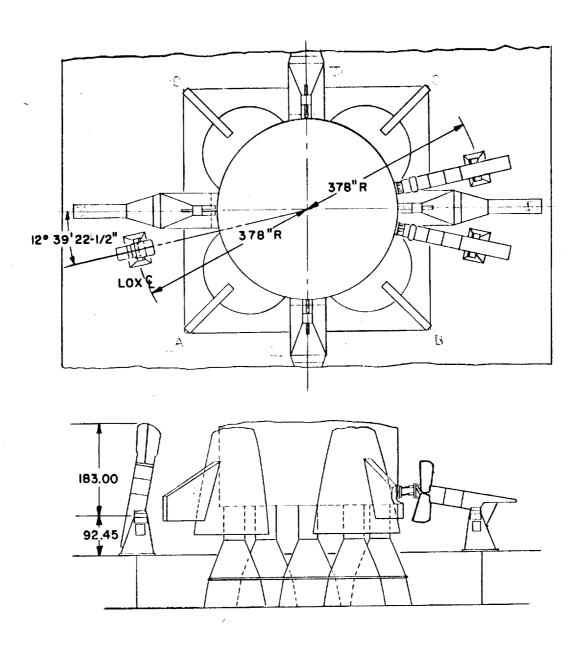


Fig. 1-3 TSM in position with Saturn V vehicle

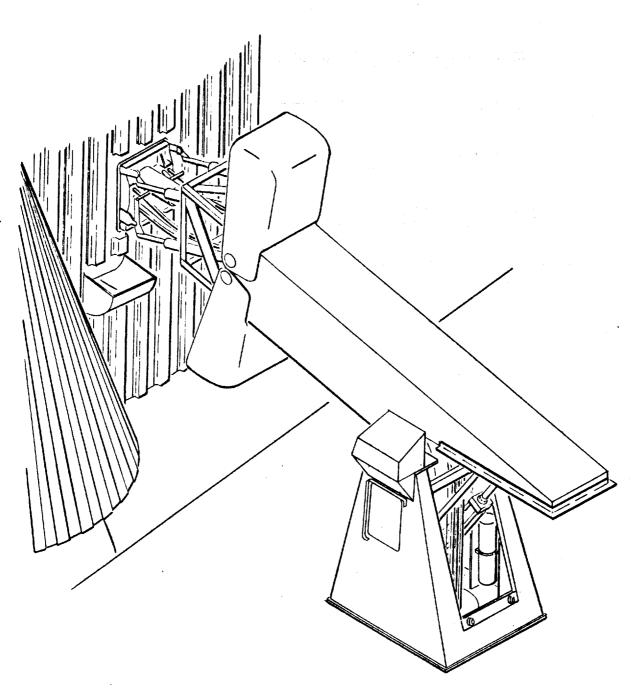


Fig. 1-4 TSM connected to Saturn V vehicle

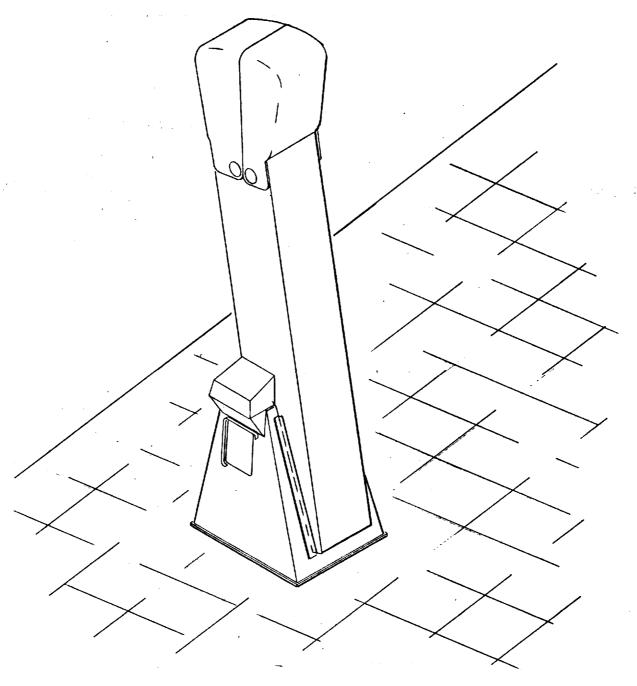


Fig. 1-5 TSM in retracted position

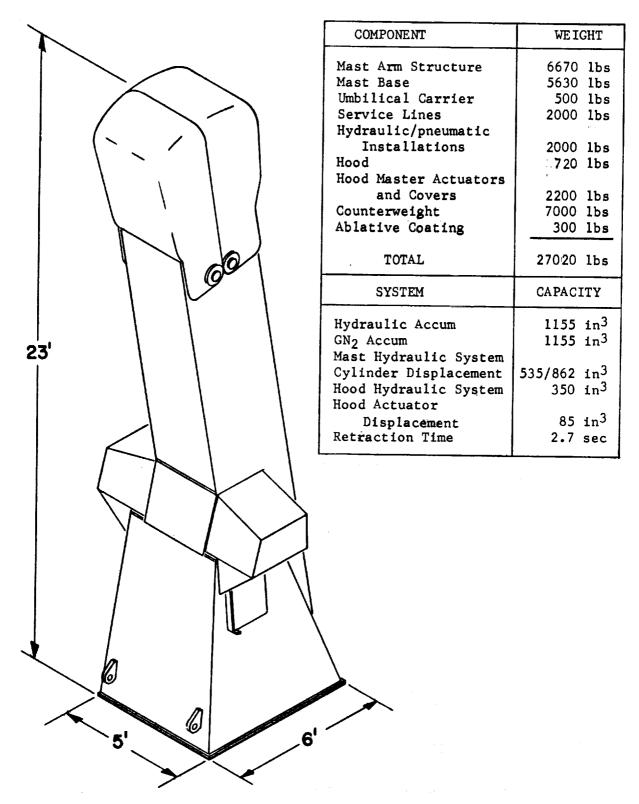


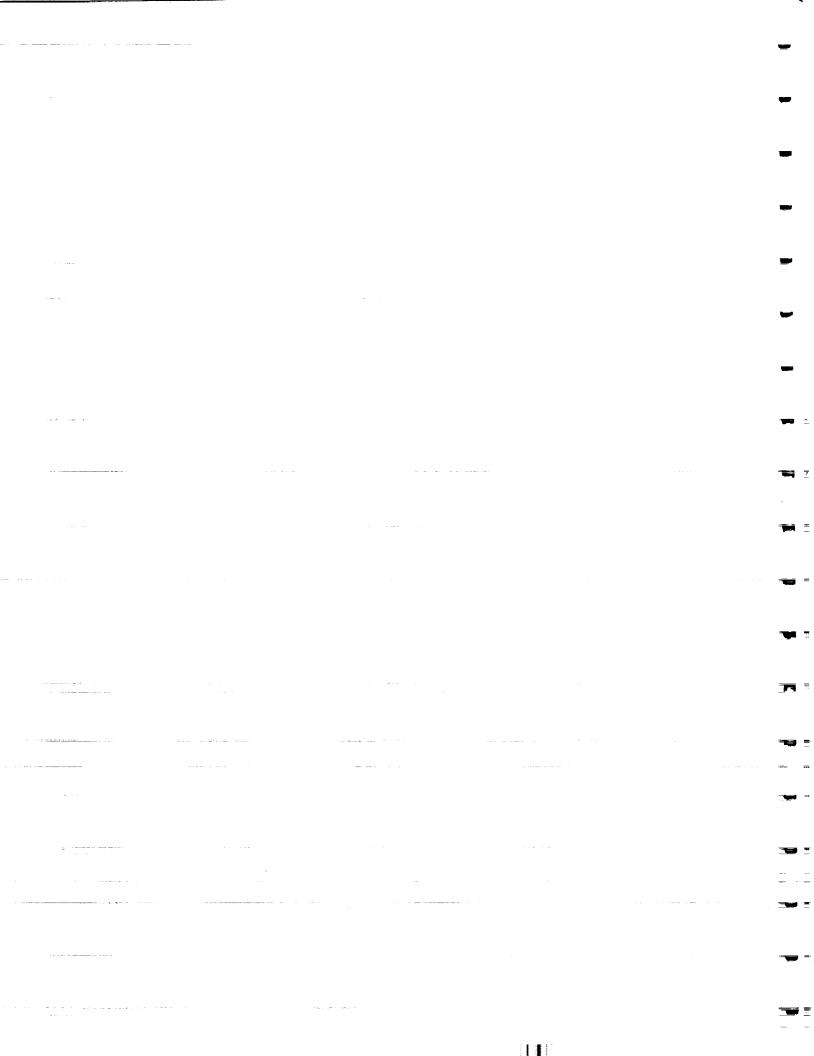
Fig. 1-6 The Tail Service Mast outline

SECTION II TAIL SERVICE MAST DESIGN

2-I DESIGN REQUIREMENTS

2-2 PRELIMINARY DESIGN

2-3 UMBILICAL CARRIER



SECTION II TAIL SERVICE MAST DESIGN

2-1 REQUIREMENTS

The basic Tail Service Mast is to be a semi-permanent structure that may be used to retract the umbilical coupling from the booster stage of the Saturn V vehicle for consecutive launchings. There are to be three Tail Service Masts which are interchangeable with the exception of service lines. It is required that the umbilical couplings remain with the vehicle until after firing and be disconnected only after the vehicle begins movement.

The Tail Service Mast must remove the umbilical ground-half from the vehicle to an area which will be clear of the vehicle flight path.

The Tail Service Mast must be capable of withstanding the severe environment produced by the F-1 engines of the Saturn V vehicle. With the Mast in the upright and final position after retract it should afford protection to the umbilical carrier and the service lines.

2-2 PRELIMINARY DESIGN

Preliminary design of the Tail Service Mast considered vertical, lateral, and a combination of vertical and lateral movement to remove the umbilical attachment.

The short time element involved to retract the umbilical carrier to a favorable position necessitated the use of a Tail Service Mast that rotated in the vertical plane. This realizes the use of a counterweight which was unnecessary for a laterally rotating mast. Engine fairings and hold-down arms prevented the use of a mast with complete lateral movement. A combination of vertical then lateral was relatively slow and presented unrealistic service line routing.

The Tail Service Mast deemed most practical was a counterweighted structure that was pneumatically-hydraulically operated. The counterweight was to serve

both as a possible means of movement in case of hydraulic or pneumatic failure and to reduce the force required for moving the mast. This provided for the use of smaller hydraulic cylinders thereby aiding the fluid flow problems encountered with high volume flows.

In order to meet the extreme environmental conditions of operating temperature, pressure, and vibration a steel structure with an ablative coating is used.

The mast movement is triggered pneumatically by the first three (3) inches vertical travel of the vehicle. It is then controlled electrically for proper sequencing. A mechanical release of the umbilical ground-half is provided in case of failure of the normal pneumatic sequence. The mechanical release will operate at approximately fifteen (15) inches vertical travel of the vehicle.

The mast utilizes the base to house the pneumatic accumulators and an electrical control panel as well as substitute connections for testing purposes.

The Tail Service Mast is provided with a lightweight hood to afford protection for the umbilical carrier during liftoff of the Saturn V vehicle. The hood is operated by a closed hydraulic system which is dependent upon rotation of the mast.

Initial design of the protective hood system included materials such as steel, aluminum, and titanium to withstand the heat and exhaust impingement of the F-l engines. These presented either excessive weight or difficult fabrication problems. A fiberglass structure reinforced with aluminum honeycomb was found to meet the design requirements most prevalent.

Due to the restricted area that could be utilized for movement of a protective hood a clam shell that operated in the vertical plane was found

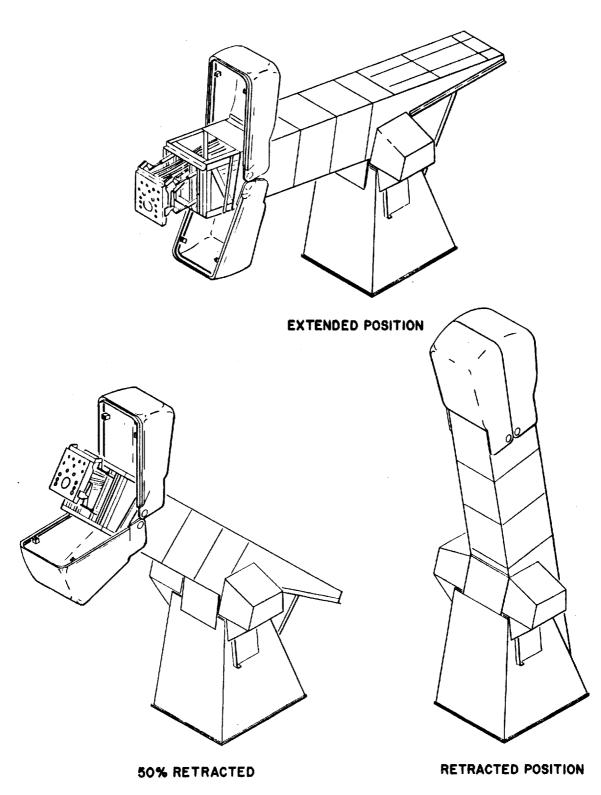


Fig. 2-1 Tail Service Mast Operating sequence

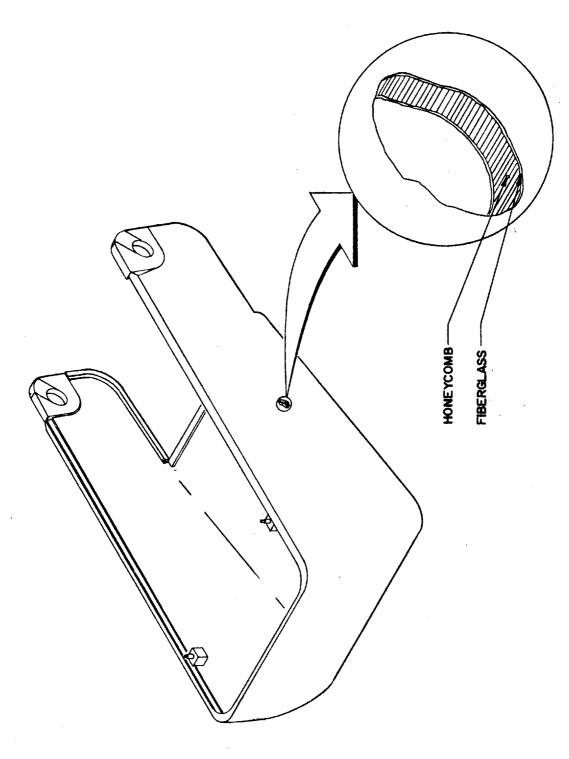


Fig. 2-2 TSM hood showing aluminum honeycomb section

to be most practical. This type necessarily must be made to overcome the effects of gravity, however, it was found that by optimum placing of the gear system the effects of gravity could partially be overcome.

2-3 UMBILICAL CARRIER

The umbilical carrier will be supplied complete for attachment to the Tail Service Mast.

The essential purpose of the carrier is to provide attachment of the service lines to the Saturn V vehicle. The disconnect mechanism will be a part of the carrier and will provide pneumatic control for triggering of the Tail Service Mast.

The first three (3) inches rise of the vehicle will operate the pneumatic release mechanism. In case of pneumatic failure the umbilical carrier will be released from the vehicle mechanically after approximately fifteen (15) inches rise from the nominal position.

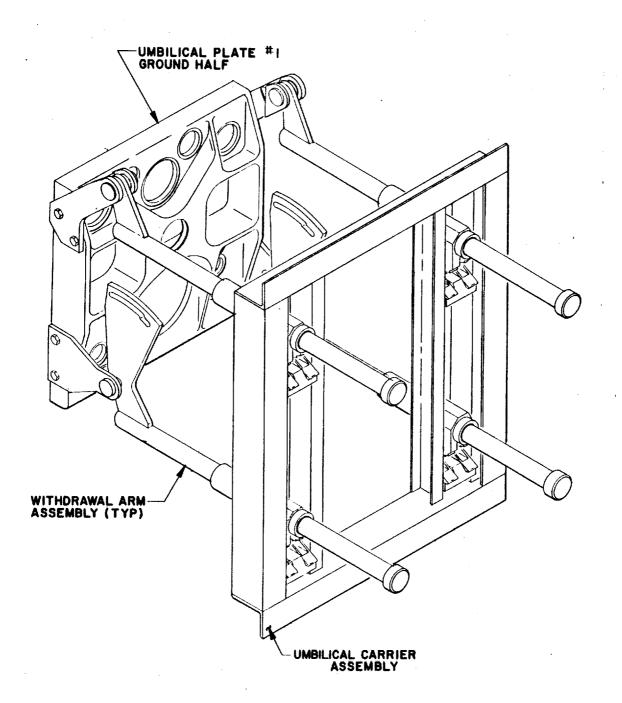
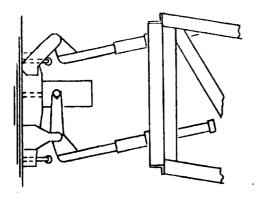


Fig. 2-3 The umbilical carrier



LOCKED POSITION

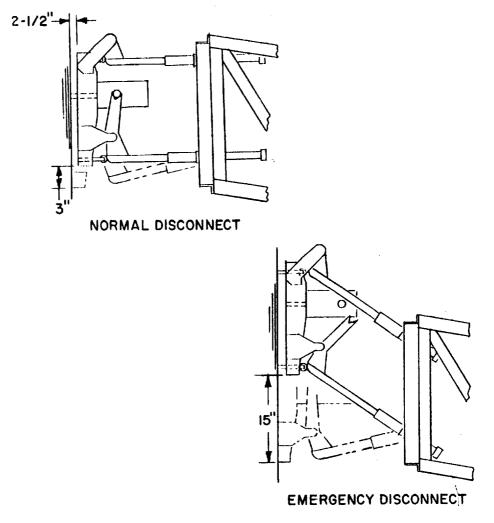
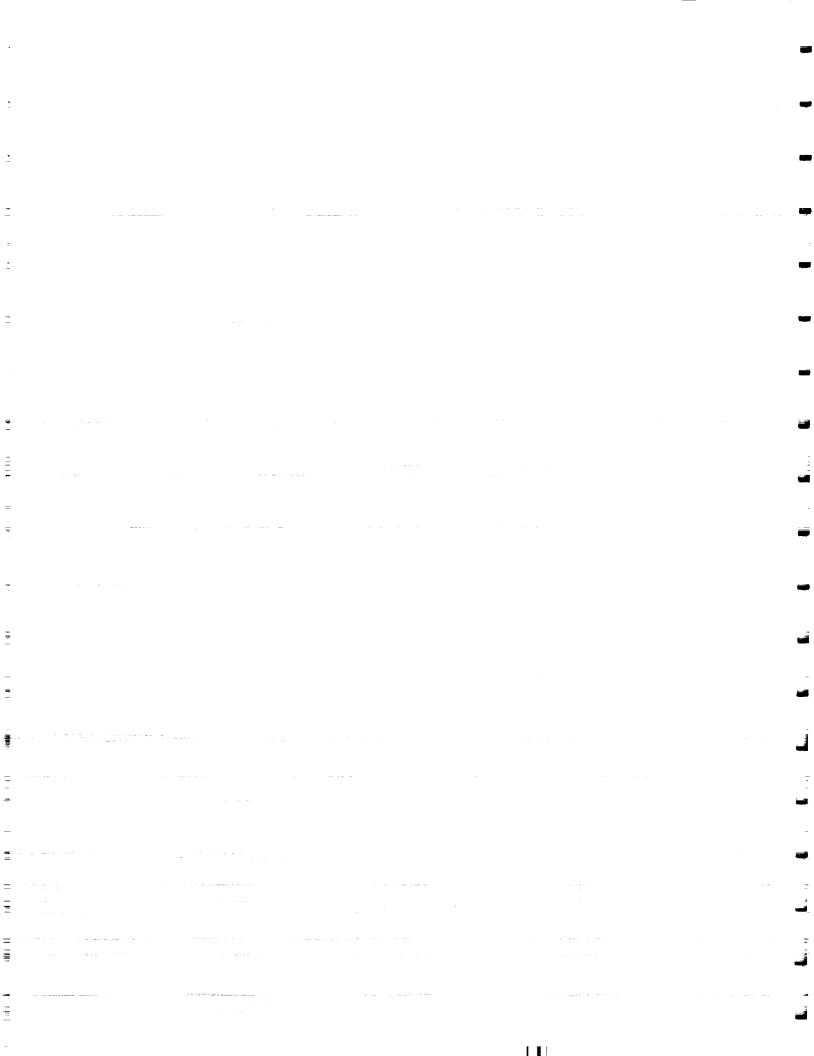


Fig. 2-4 Umbilical carrier operating sequence

SECTION III DESCRIPTION

- 3-I TAIL SERVICE MAST ARM
- 3-2 TAIL SERVICE MAST BASE
- 3-3 TAIL SERVICE MAST HOOD
- 3-4 PROTECTIVE HOOD HYDRAULIC SYSTEM
- 3-5 TAIL SERVICE MAST PNEUMATIC -HYDRAULIC SYSTEM
- 3-6 ELECTRICAL SYSTEM



SECTION III DESCRIPTION

3-1 TAIL SERVICE MAST ARM

The arm structure is the main component in the Tail Service Mast. It serves as a carrier for and affords protection to the service lines.

The arm structure is fabricated of angle irons and Tee type stiffeners of structural steel meeting the specifications for QQ-S-741, grade "B". The allowable stress used in design calculations is equal to the yield strength divided by a safety factor of three (3). High strength steels were not considered since the calculated stresses were well below allowable. The aft section of the arm houses the counterweight section and is of heavier construction than the forward structure. This is due to the lead counterweight and the fact that the mast driving cylinders are attached to this section.

Each mast arm structure is provided with an adjustable counterweight to compensate for the difference in the service lines carried.

The arm frame is covered with a 3/16 inch skin plate which will be covered with an ablative coating during firing. The ablative coating will maintain the temperature of the inside of the mast to near initial ambient conditions.

3-2 TAIL SERVICE MAST BASE

The basic function of the Tail Service Mast base is to provide a pivot for the mast arm and to house equipment that is essential for testing and operation.

The base is constructed of structural steel angle irons and tee sections.

The base is a massive structure capable of withstanding the weight of the mast arm and the impact forces encountered during retraction.

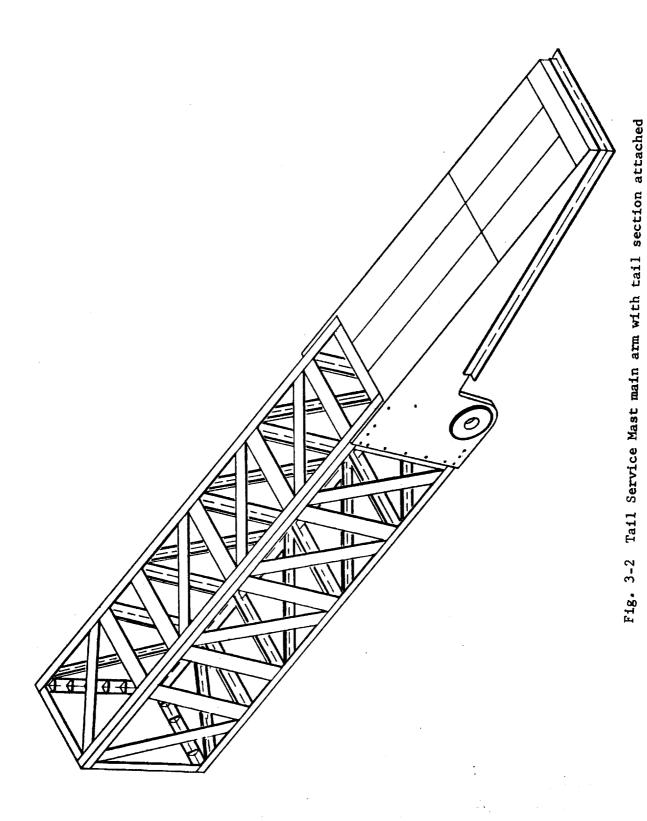
The skin plate of 3/8 inch steel covering three sides of the base should be sufficient to retard the jet-wash presented by the passing F-1 engines during lift-off. The fourth side of the base will be covered by the tail section of

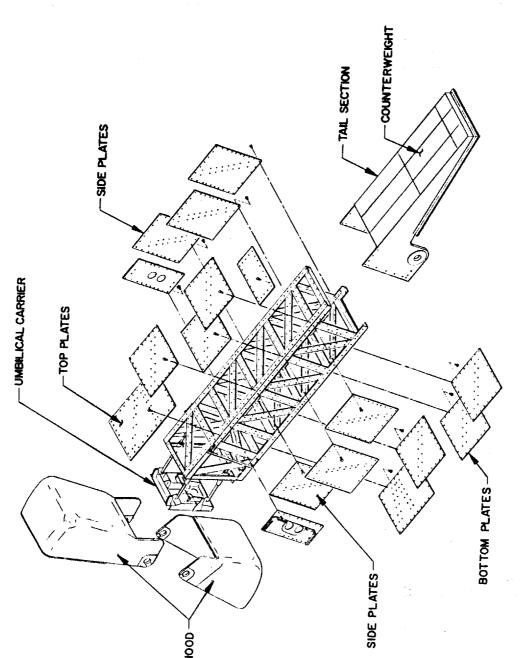


Fig. 3-1 Tail Service Mast front arm during fabrication

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g. 3.3 TSM arm showing hood, skin plates, and tail section

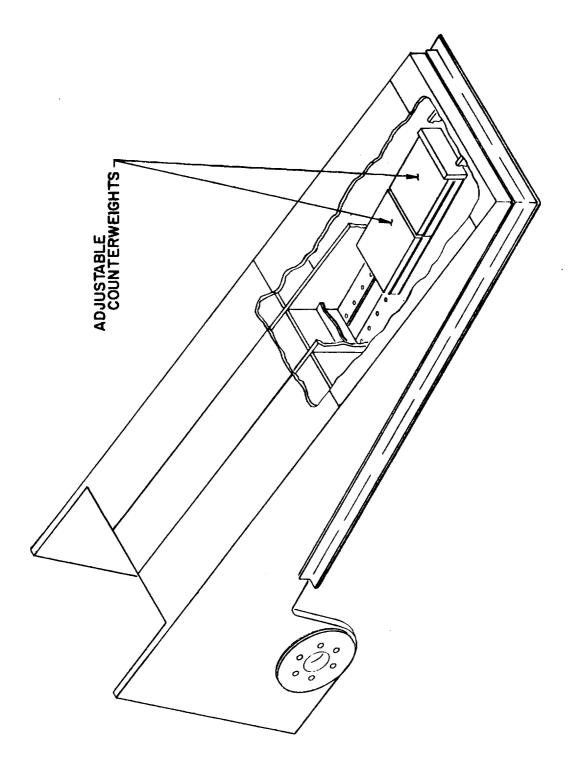


Fig. 3-4 TSM tail section showing adjustable counterweight

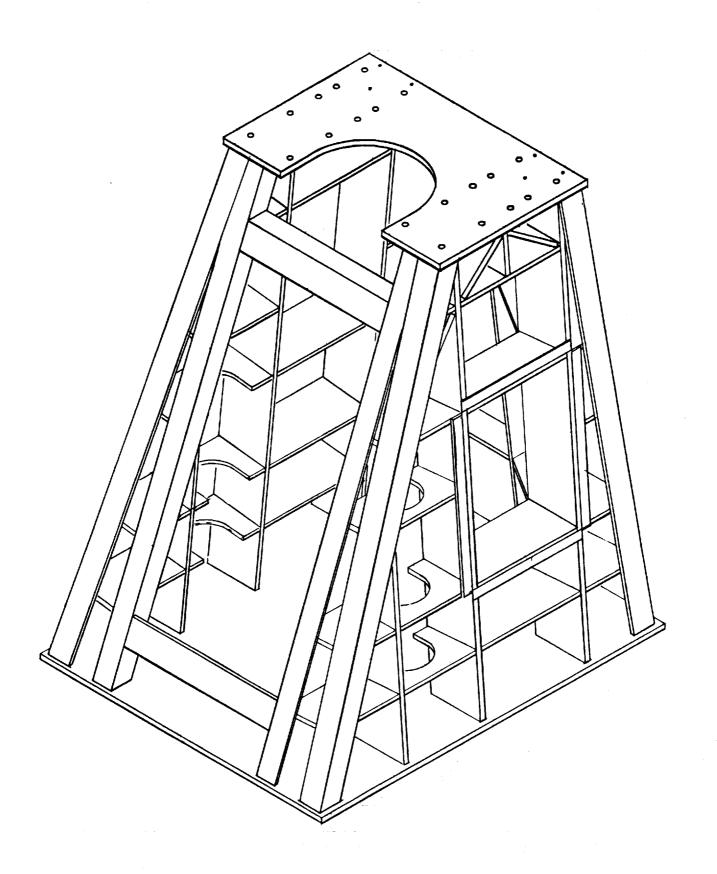
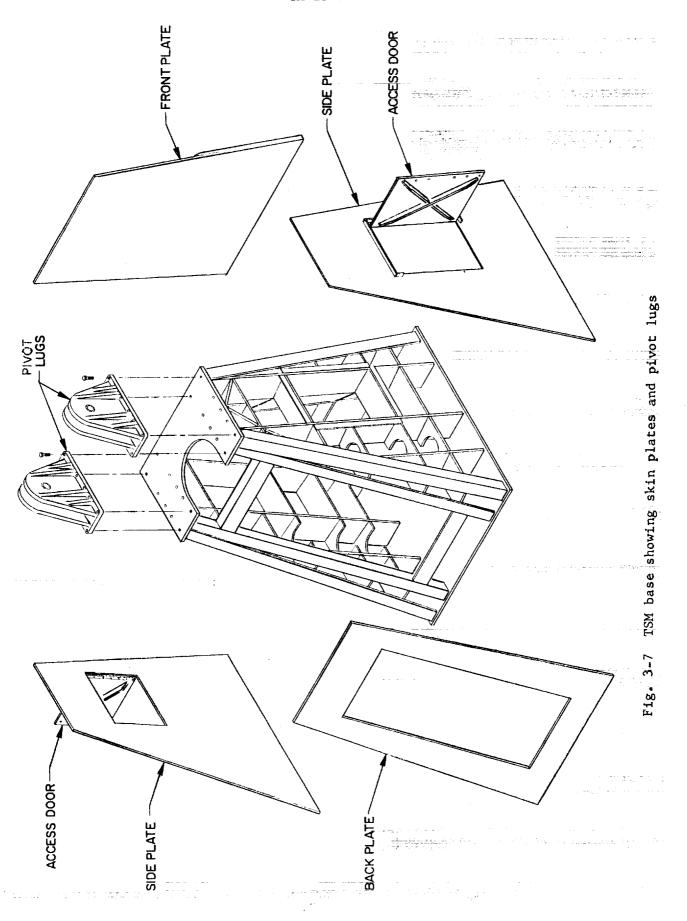
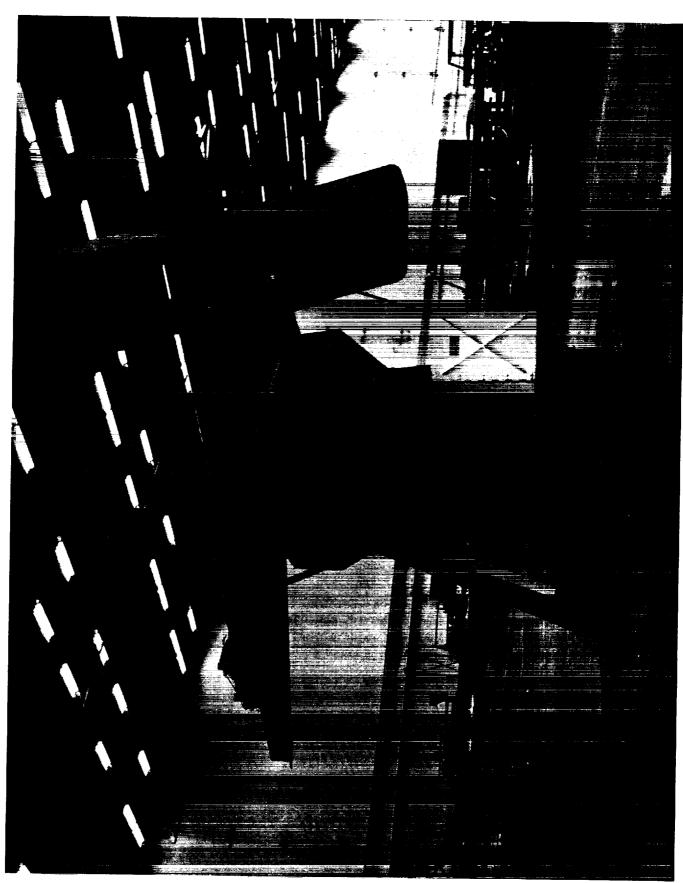


Fig. 3-5 Tail Service Mast base showing supporting structure



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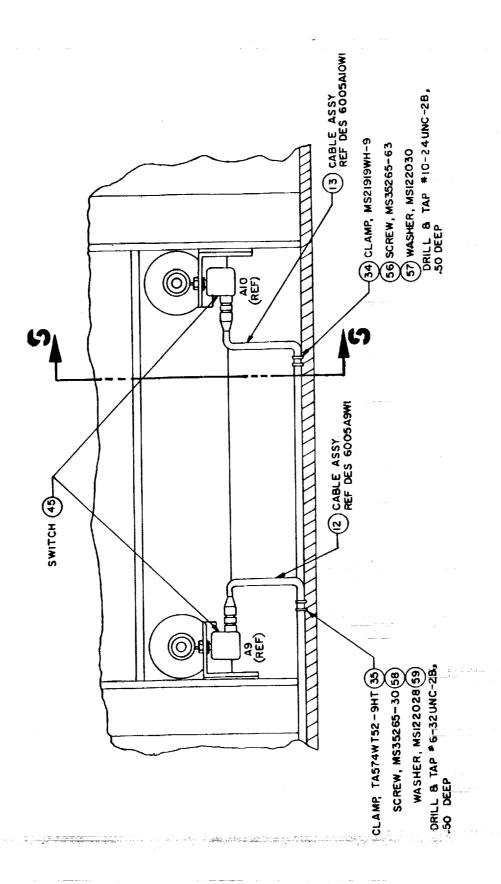


Fig. 3-9 Ball locks located in base of mast

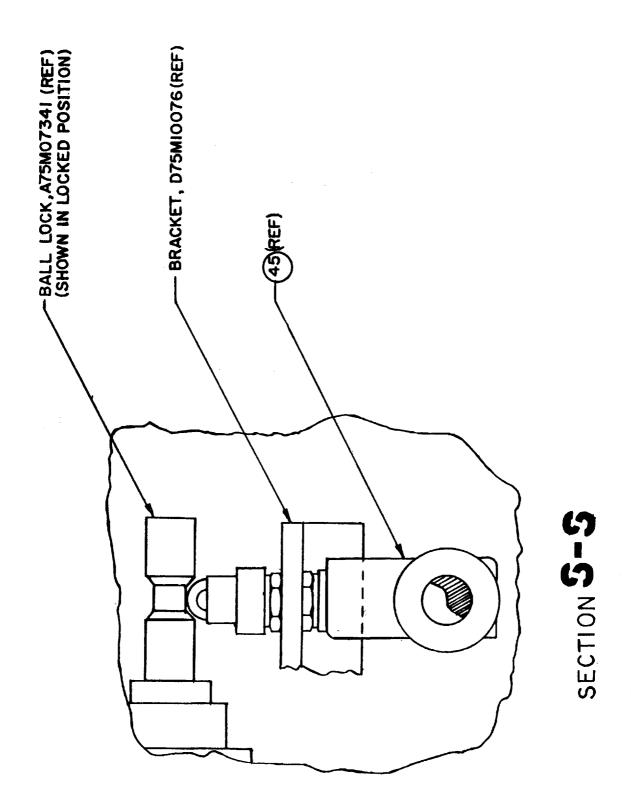
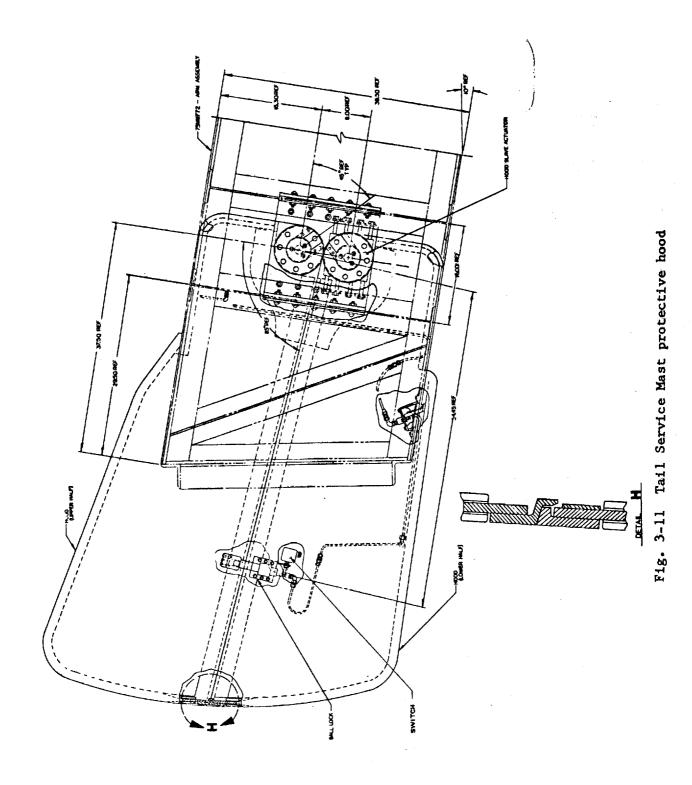


Fig. 3-10 Detail of base ball lock limit switch installation



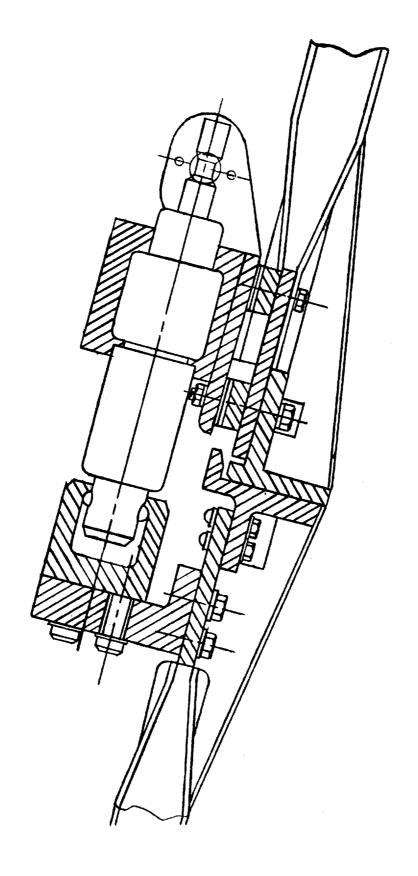


Fig. 3-12 Detail of hood ball lock installation

the mast arm which is designed for a close fit. Mechanical locks are provided in the base for holding the mast arm in the retracted position.

The base is provided with an access door on one side and an instrument panel on the other side for use in testing and checkout.

3-3 TAIL SERVICE MAST HOOD

The main purpose of the hood is to provide protection to the umbilical attachment from engine blast after vehicle lift-off.

For strength and rigidity the hood is fabricated from aluminum honeycomb sandwiched between layers of fiberglass.

Each half of the clamshell structure is driven in relation to the other half. The parts being synchronized through a simple gear system. One half cannot rotate without causing its counterpart to rotate. This is intended to equalize the relative accelerations of the two halves, thereby requiring less torque for actuation.

3-4 HOOD HYDRAULIC SYSTEM

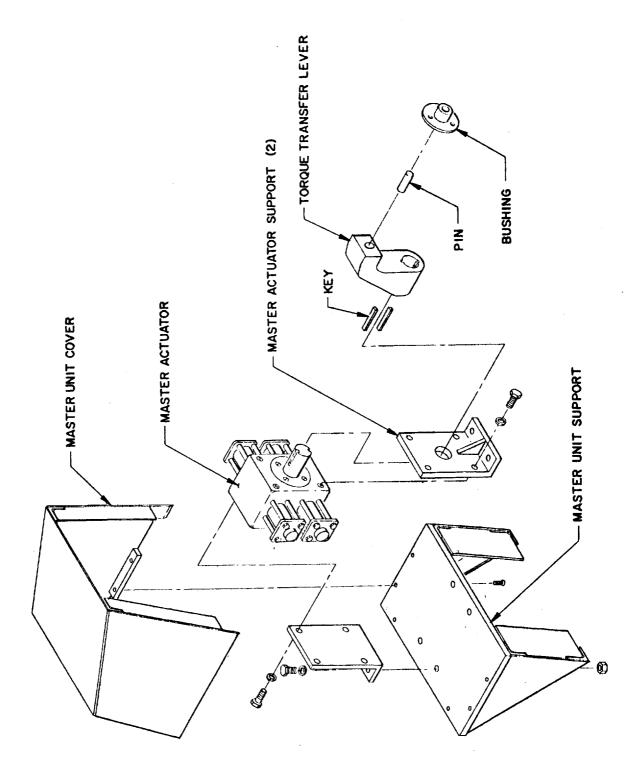
The hood motor section is a completely closed hydraulic system. The system consists of four (4) piston operated rotary actuators. The driving or master actuators are located at the pivot of the mast arm structure and derive their power from the rotation of the mast. The driven or slave actuators are located inside the mast at the hood pivot point. The four units are interconnected with hydraulic lines.

The hood will have a delayed action which may be set by a four way cam valve. This delayed action is to prevent interference of the hood with the flight path of the vehicle. The four way cam valve cycles fluid into the return side only of the master actuators for approximately the first twenty-six degrees (26°) rotation of the mast. The fluid is then cycled through the slave actuators

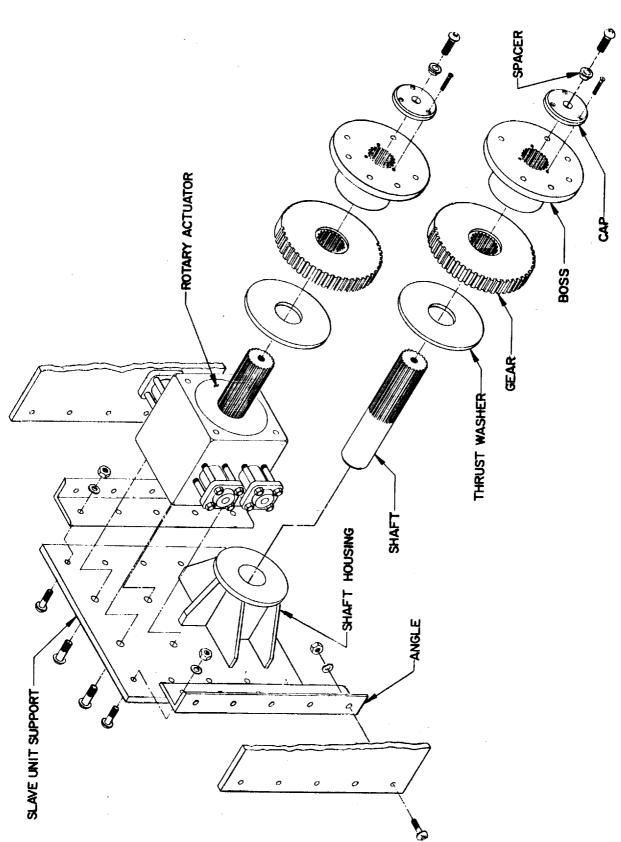
Fig. 3-13 Hood showing aluminum honeycomb construction.

Fig. 3-14 Hood showing aluminum honeycomb construction.

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Hood master actuator with supporting structure and cover Fig. 3-15



Hood slave actuator showing upper drive shaft and lower driven shaft Fig. 3-16

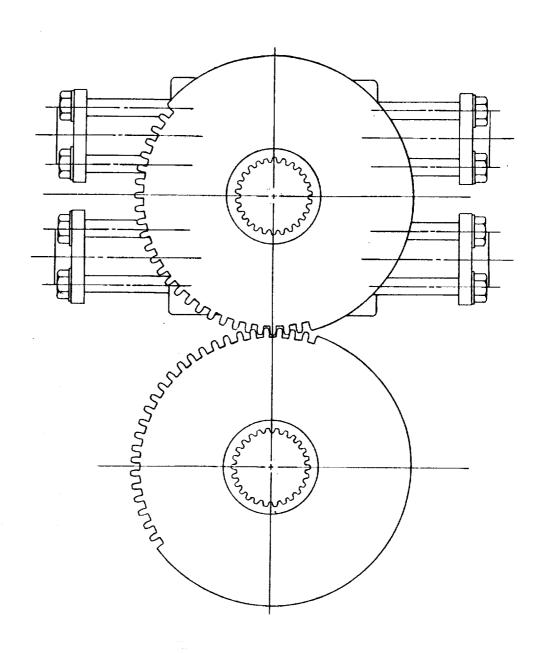


Fig. 3-17 Slave actuator upper and lower driving gears

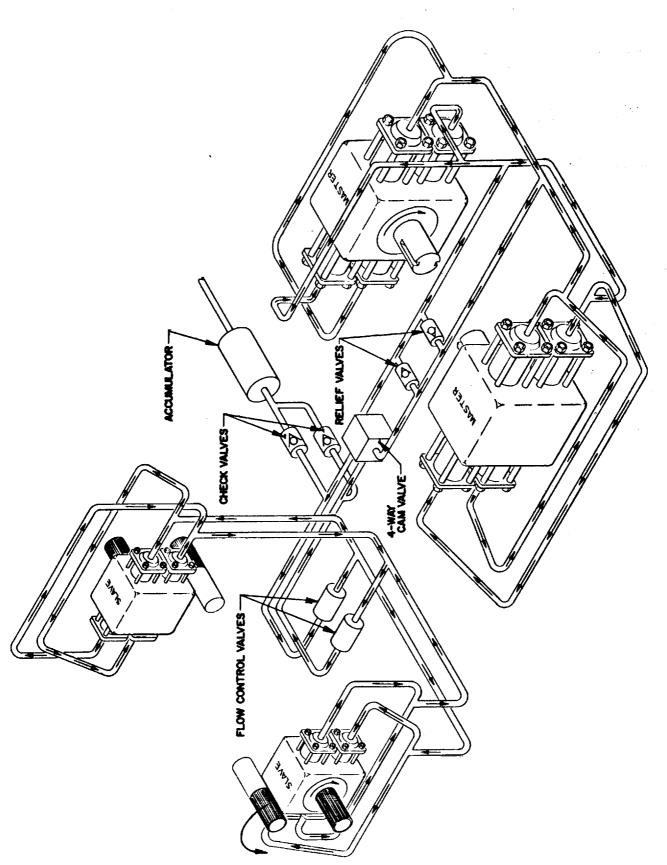
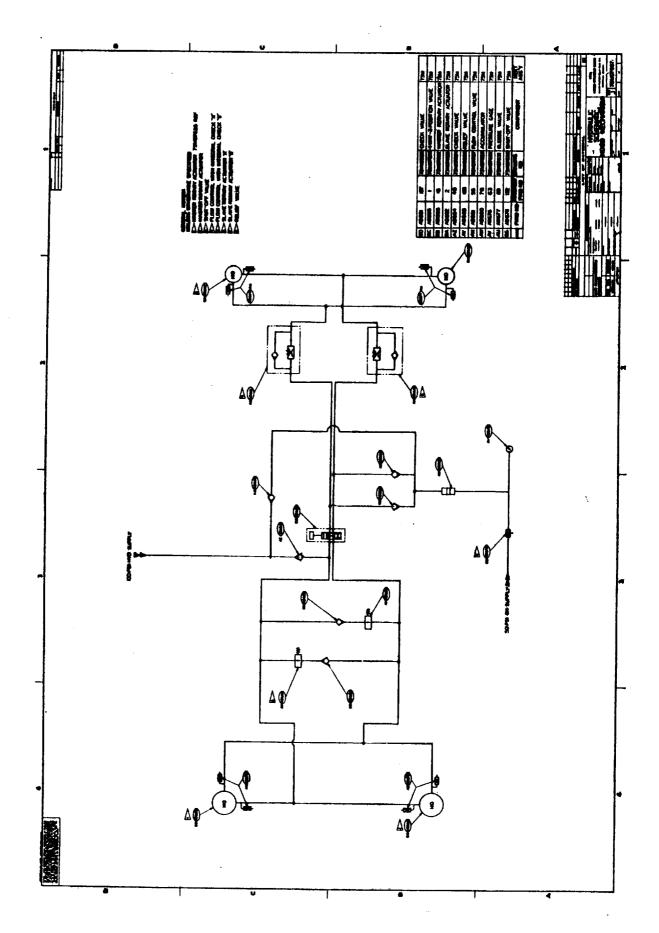


Fig. 3-18 Hood closed hydraulic system





causing rotation of the hood. A relief valve is positioned between the supply and return lines of the slave units to prevent excessive pressure build-up.

A variable orifice is included in the circuit downstream of the slave actuators to provide control of the angular velocity of the hood.

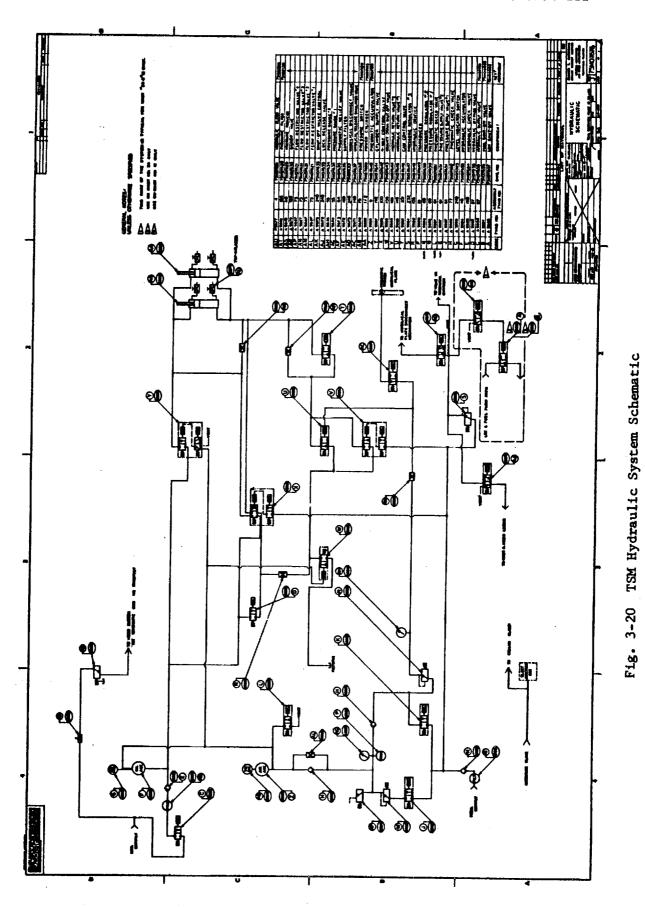
3-5 TAIL SERVICE MAST HYDRAULIC SYSTEM

The motor section for operation of the Tail Service Mast is pneumaticallyhydraulically operated.

The use of hydraulic operated cylinders instead of rotary actuators was required due to the power requirements. Placement of the cylinders, however, had to be a compromise between mechanical advantage and position for optimum control.

Two 3 1/4 inch bore cylinders with a 2 inch shaft are utilized. The cylinders are connected to the hydraulic circuit in parallel for scyncronization. The one (1) inch output line of each cylinder is connected to a common one and a half (1 1/2) inch line containing the cam control valve. Hydraulic supply for the Tail Service Mast is independent of that for the Launch Umbilical Tower (LUT). The system supply consist of two 1155 cubic inch accumulators. One accumulator is used for GN2 as a pressure supply. The other accumulator is a reservoir for hydraulic fluid. Once the GN2 accumulator is pressurized it may be sealed off, thereby, becoming independent of the LUT or test cart. Both accumulators were calculated to supply 25% in excess of requirements.

The control valve to initiate operation of the Tail Service Mast is located in the downstream position. The control valve is connected to the umbilical attachment by way of a bleed coupling. Separation of the umbilical ground-half from the fly-half will allow loss of pressure in the valve actuator



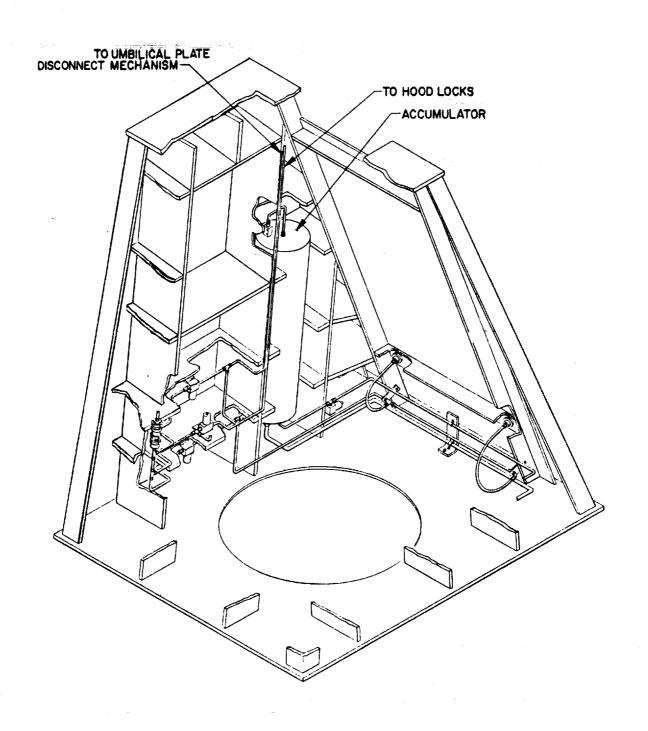
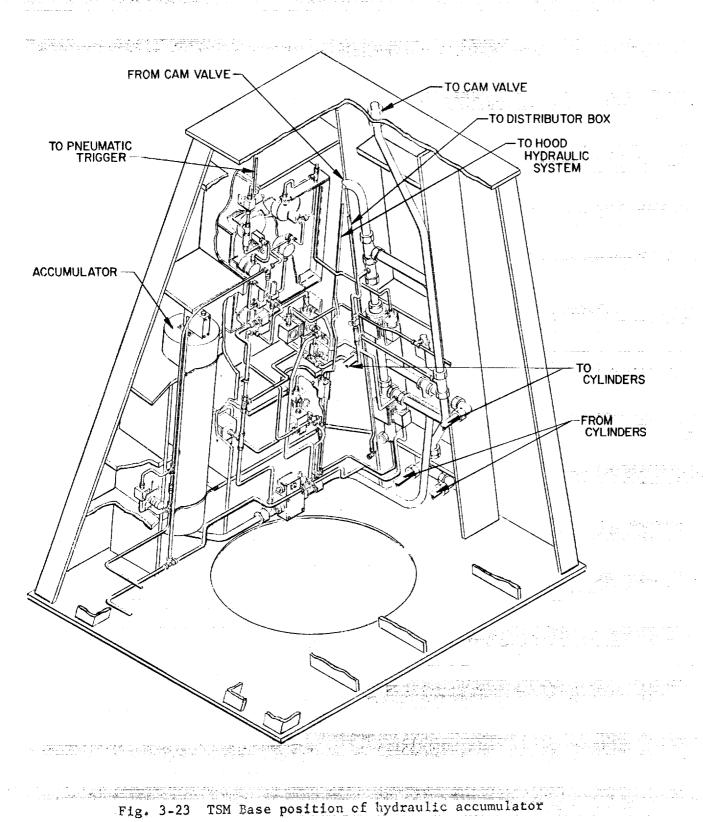


Fig. 3-21 TSM Base position of GN_2 accumulator

Fig. 3-22 TSM Base showing hydraulic cylinders, LOX line, and $\ensuremath{\text{GN}_2}$ accumulator.



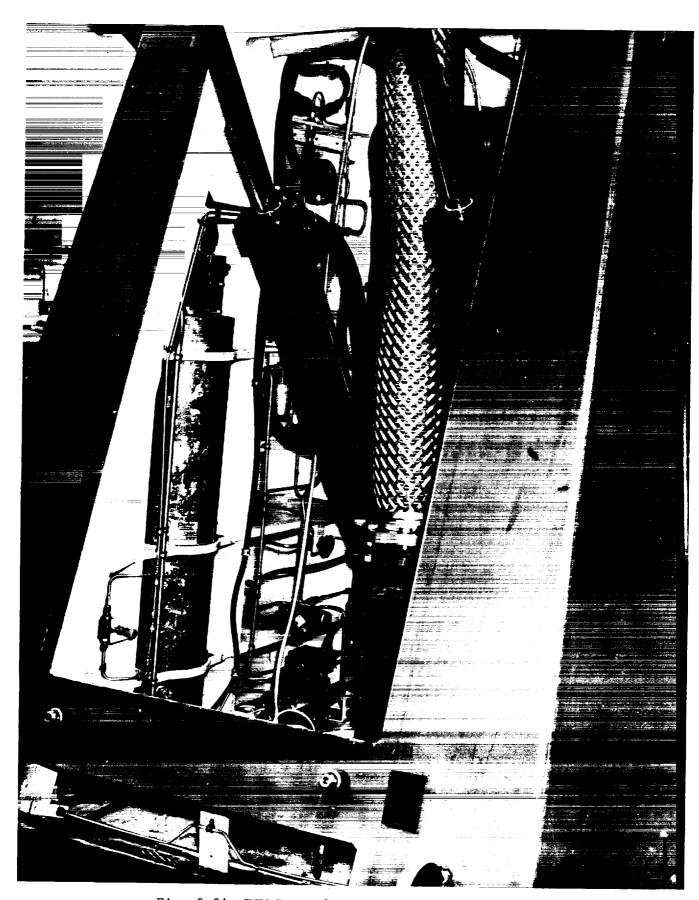


Fig. 3-24 TSM Base showing hydraulic accumulator

opening the valve. To assure operation of the control valve an electrically operated control valve is placed in parallel with the pneumatically operated valve. Electrical control is provided by separation of the umbilical attachment.

3-6 ELECTRICAL SYSTEM

The Tail Service Mast pneumatic triggering system is paralleled with an electrical system as a fail-safe feature. A limit switch is located between the fly-half and ground-half of the umbilical attachment. The limit switch is connected to a control valve by-pass which will insure an alternate path for hydraulic fluid in the event of main control valve failure.

Once the Tail Service Mast is triggered either pneumatically or electrically control for electrical sequence is established. The operation of each Fail Service Mast is monitored by way of an electrical distributor located in the mast base. All electrical signals from hydraulic and pneumatic components are relayed through the distributor to either test set 7601 or to the Launch Control Center. For the test set outside cables are connected to the distributor through the access door in the mast base. During operation from the Launch Umbilical Tower connections to Launch Control Center is made via the interface plate in the base.

The test set is a portable unit complete with cables used to control and monitor operation of the Fail Service Mast during test. The test set is connected to the distributor located in the base of the mast and to a 28 vdc power supply with cables supplied with the test set. After pneumatic and hydraulic connections have been made to the mast the test set is used to prepare, check, and operate the Fail Service Mast from a remote position.

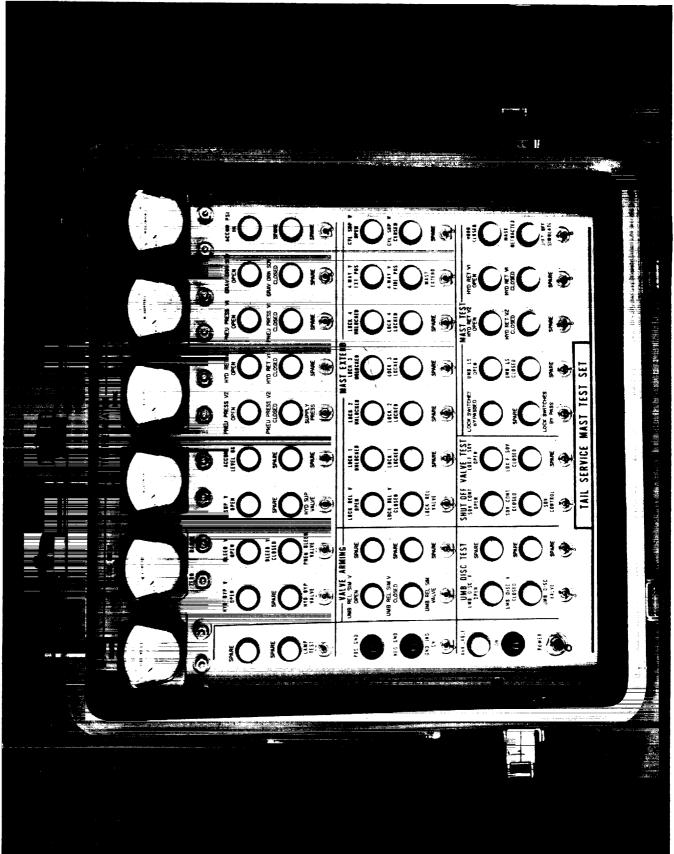


Fig. 3-25 Tail Service Mast Test Set 7601

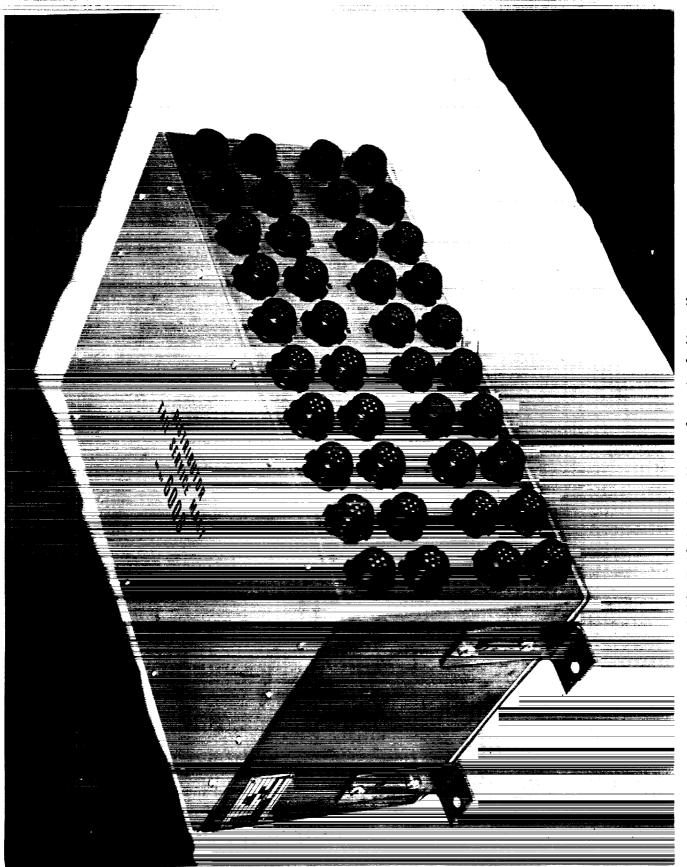


Fig. 3-26 Tail Service Mast electrical distributor

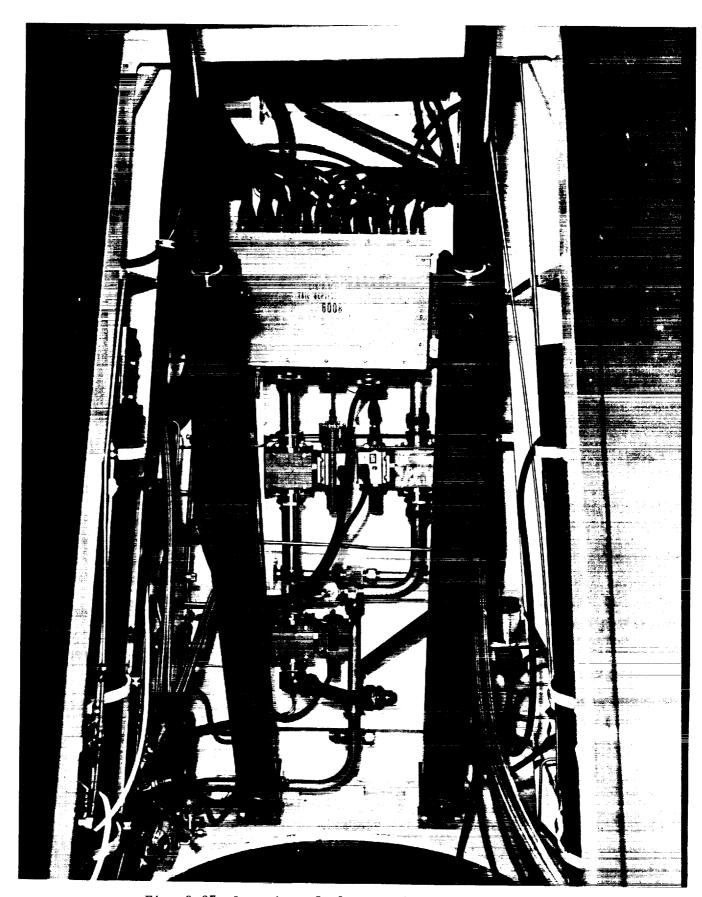


Fig. 3-27 Location of Electrical distributor in base

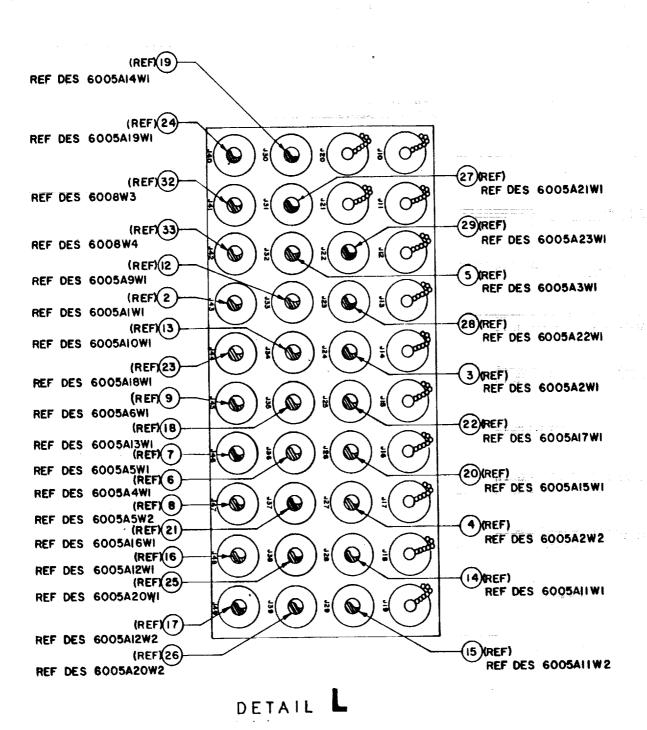


Fig. 3-28 Electrical distributor mark-up

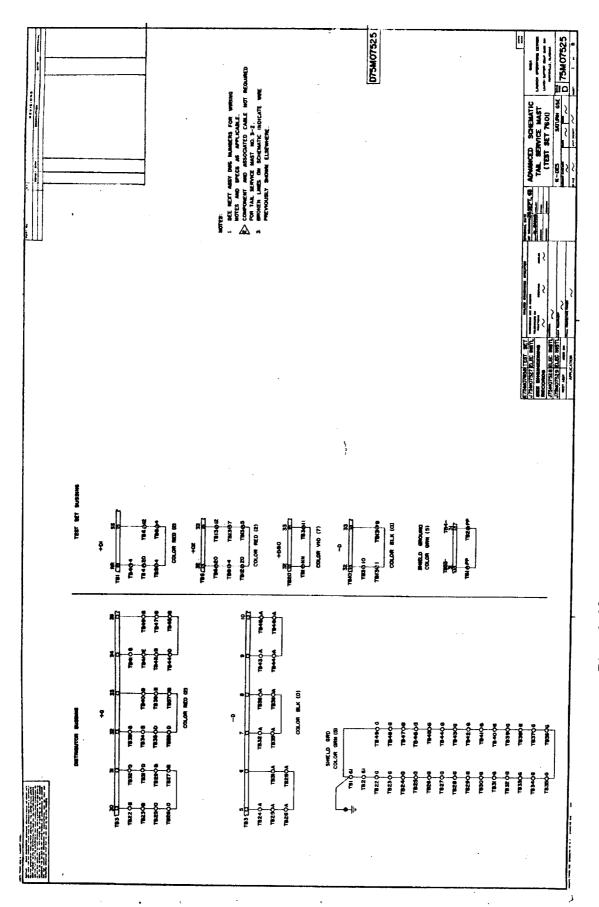


Fig. 3-29 Advanced Schematic (Test Set 7601)

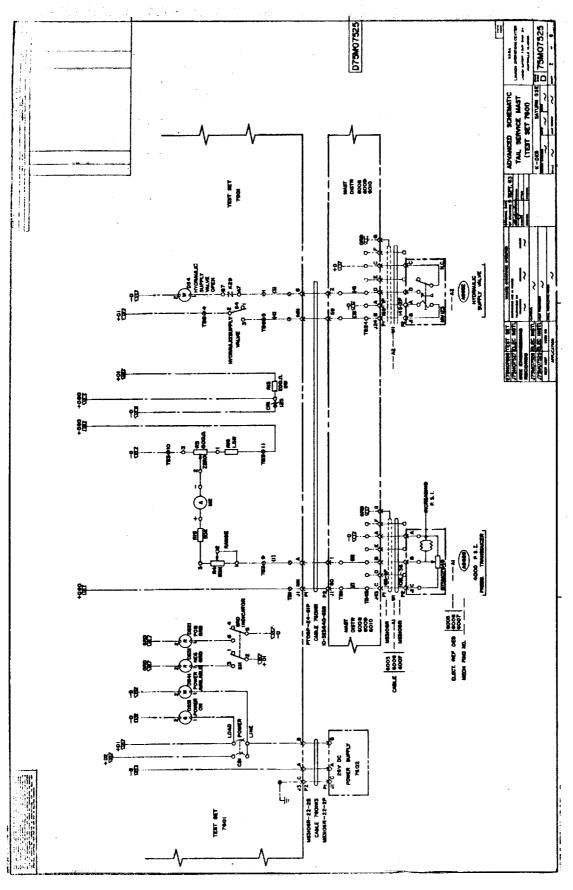


Fig. 3-30 Advanced Schematic (Test Set 7601)

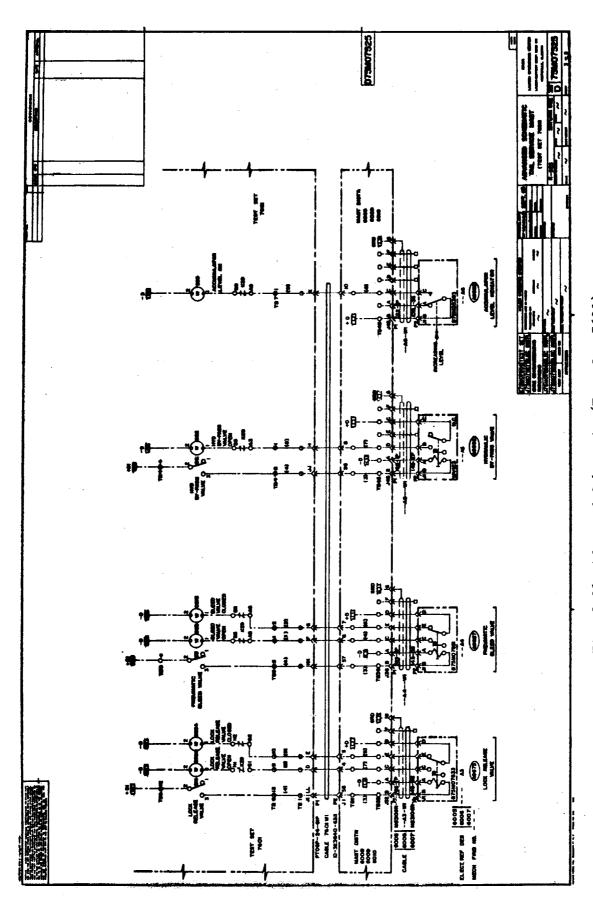


Fig. 3-31 Advanced Schematic (Test Set 7601)

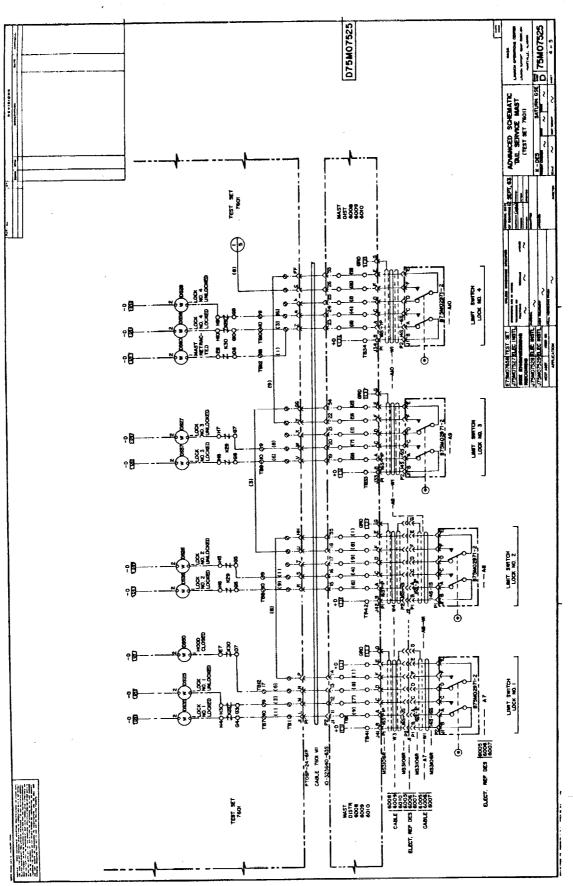


Fig. 3-32 Advanced Schematic (Test Set 7601)

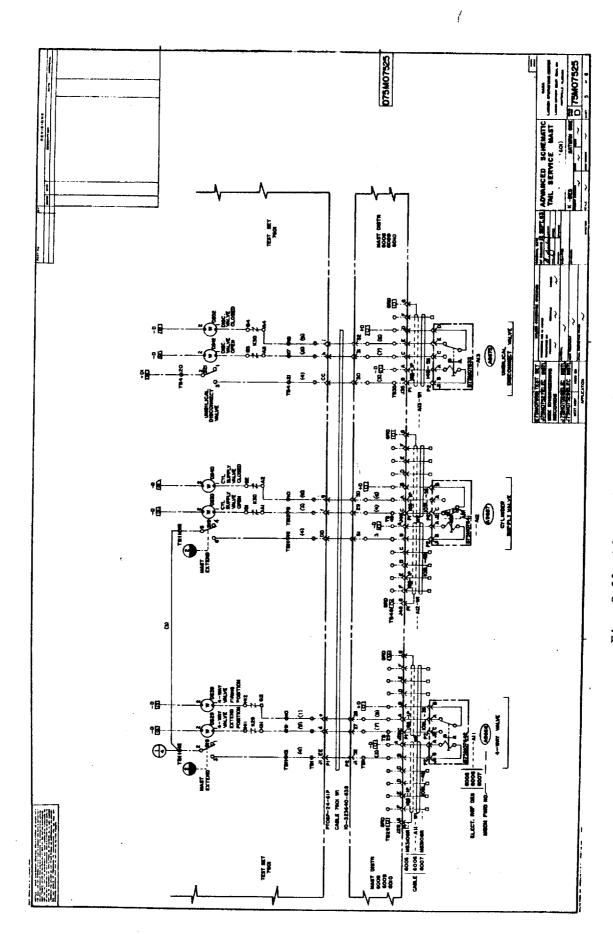


Fig. 3-33 Advanced Schematic (Test Set 7601)

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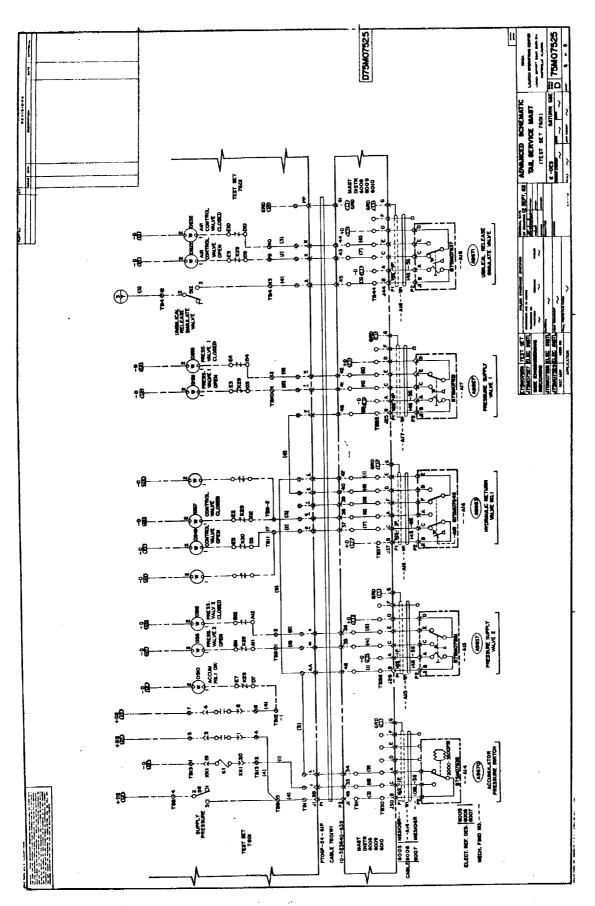


Fig. 3-34 Advanced Schematic (Test Set 7601)

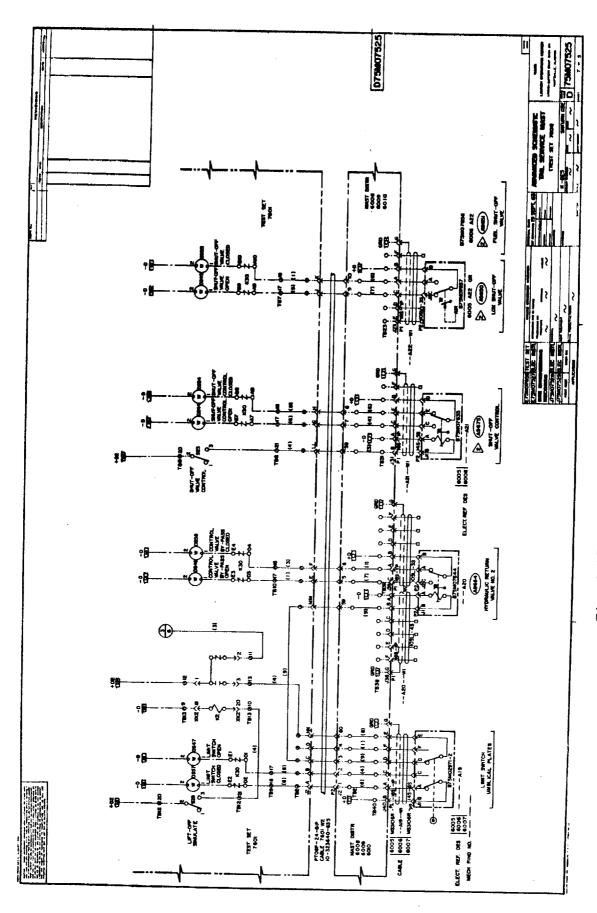


Fig. 3-35 Advanced Schematic (Test Set 7601)

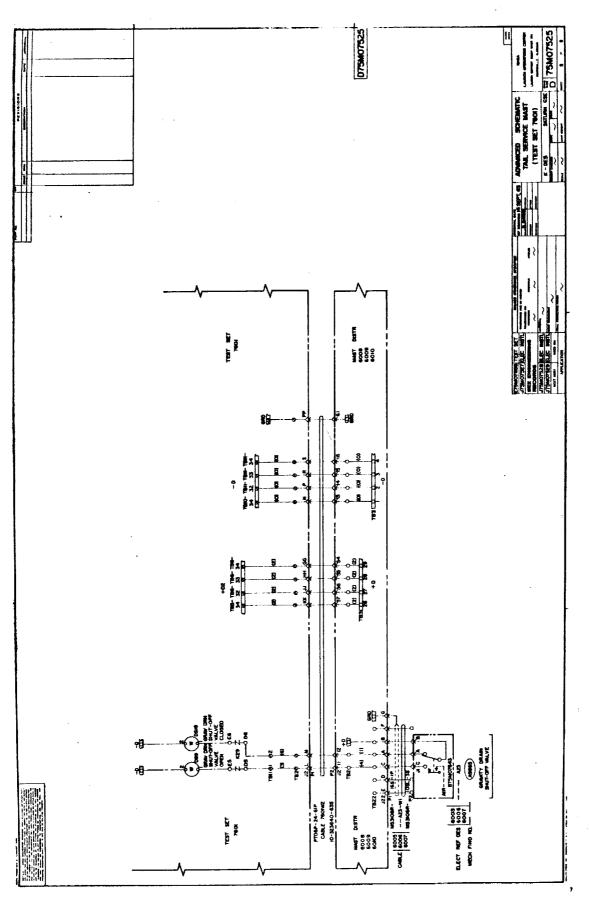


Fig. 3-36 Advanced Schematic (Test Set 7601)

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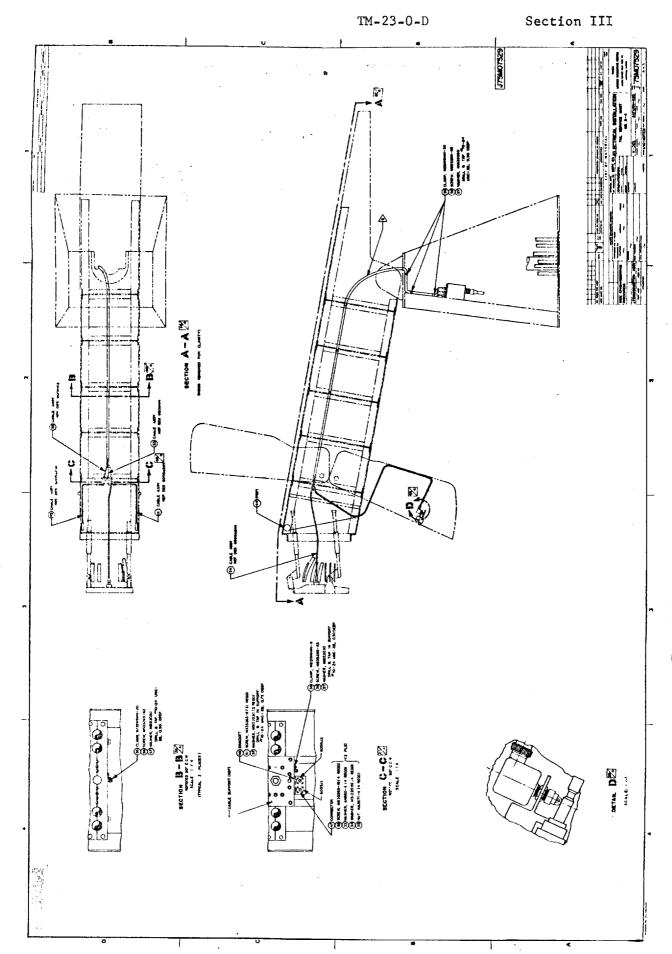


Fig. 3-37 Electrical installation on TSM 3-4

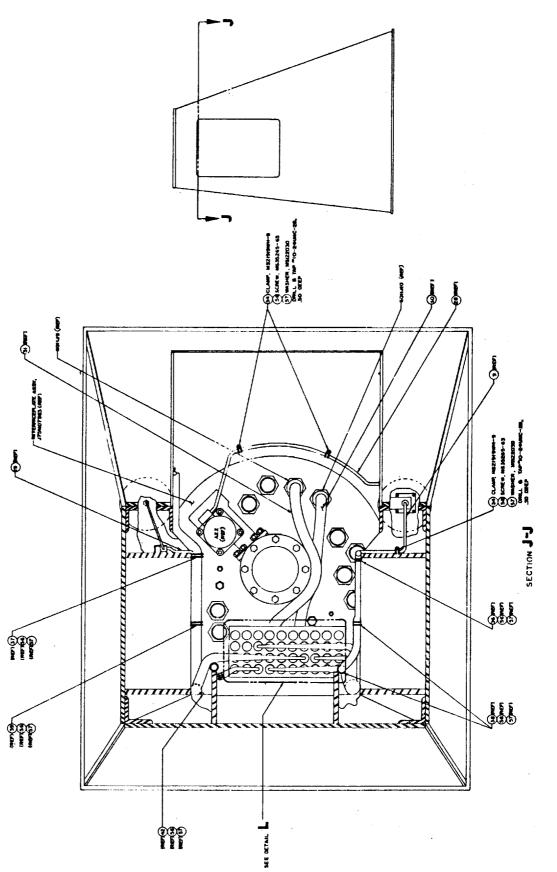


Fig. 3-38 TSM base electrical installation

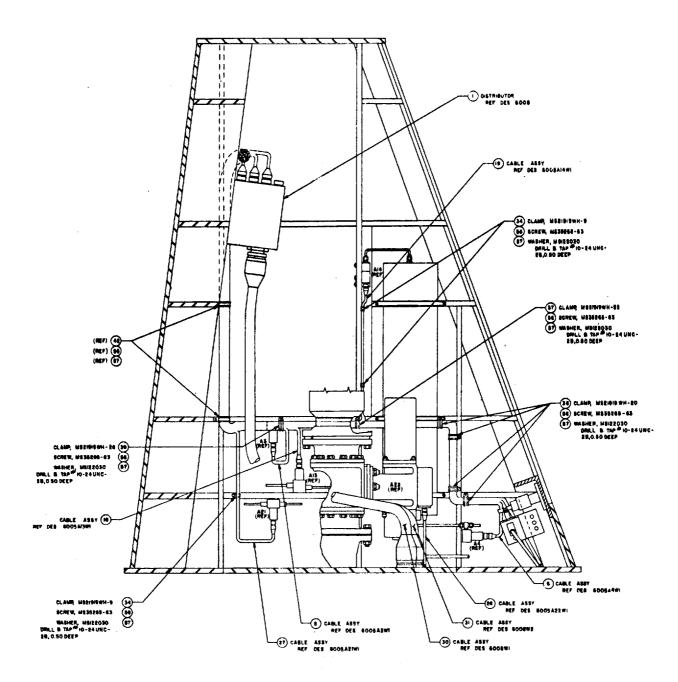


Fig. 3-39 TSM base electrical installation

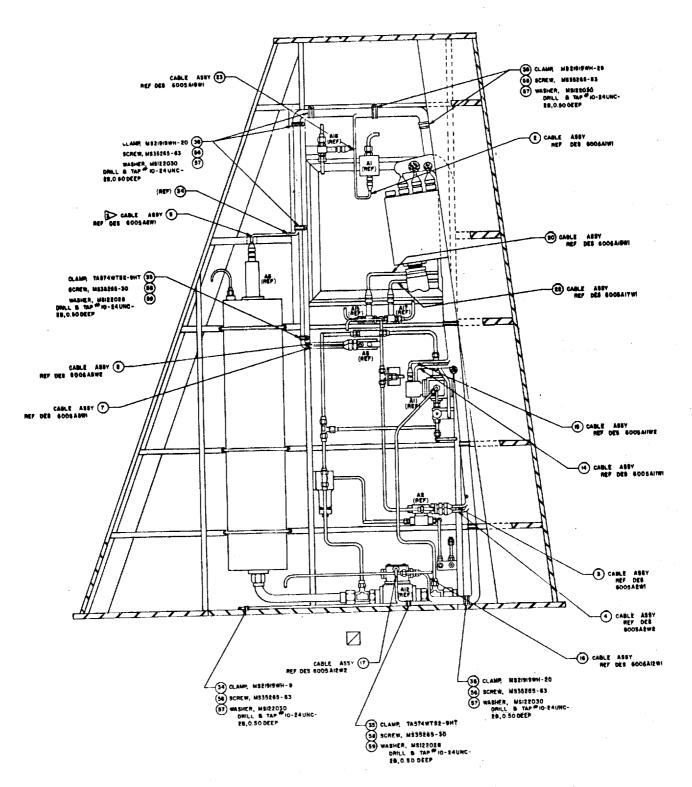


Fig. 3-40 TSM base electrical installation

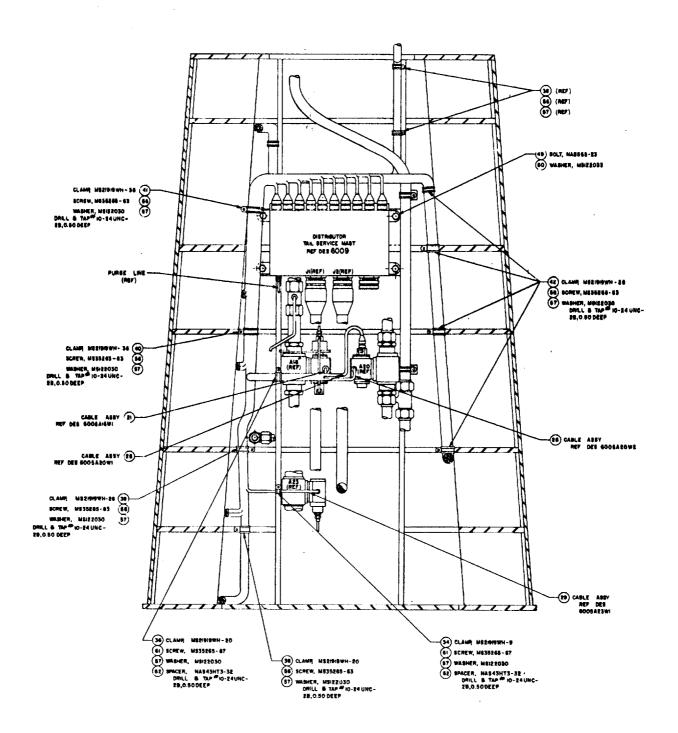
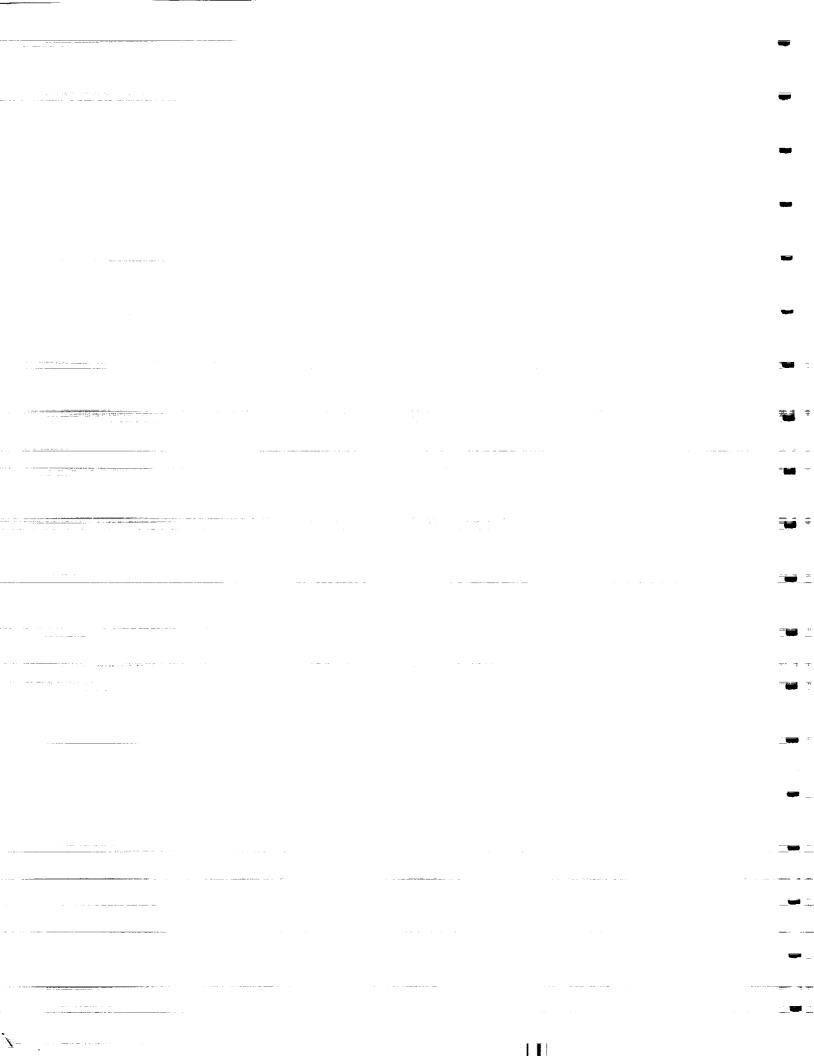


Fig. 3-41 TSM base electrical installation

SECTION IV TAIL SERVICE MAST INSTALLATIONS

- 4-1 TAIL SERVICE MAST ACTUATING SYSTEM INSTALLATION
- 4-2 PROTECTIVE HOOD INSTALLATION
- 4-3 SERVICE LINES INSTALLATION
- 4-4 TAIL SERVICE MAST HANDLING AND TRANSPORTATION



SECTION IV TAIL SERVICE MAST INSTALLATIONS

4-1 TAIL SERVICE MAST ACTUATING SYSTEM INSTALLATION

The Tail Service Mast actuation system is basically pneumatically—hydraulically operated. Such a system requires a low contamination level throughout installation. Filters have been provided as a precaution, but are not intended as a substitute for cleanliness. Extreme care should be used in preparing and installing components. Care should be taken with all fittings and flared tubing to insure that they are free from burrs and contamination.

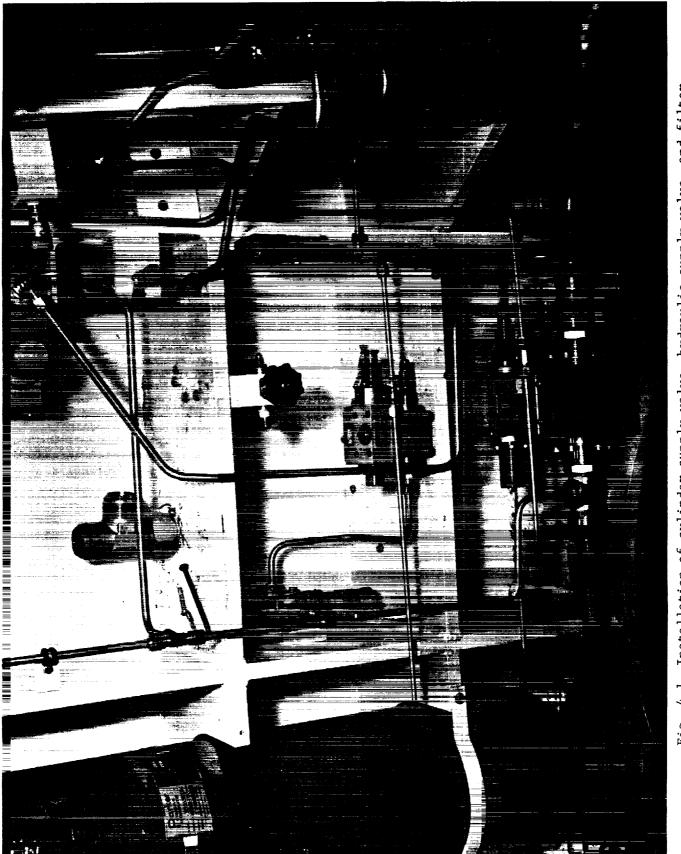
The fittings used in this installation are of the "MC" NASA standard type. These fittings are machined within the range of 18 to 32 micron finishtion the sealing surfaces. Extreme care should be used not to damage these surfaces.

The actuation system is of the two cylinder dependent type. For maximum efficiency the hydraulic lines have been routed to give as close as possible the same pressure at both pistons. The hydraulic system installation has been designed with regard to the service line installation for best utilization of space. Placement of the stainless steel tubing and valves in the actuation system is sometimes critical and reference to the proper drawing number should be made.

NOTE

Prior to installing any component, visually inspect for cuts, abrasions, dents, burrs, loose connections, cracks, and any other defects.

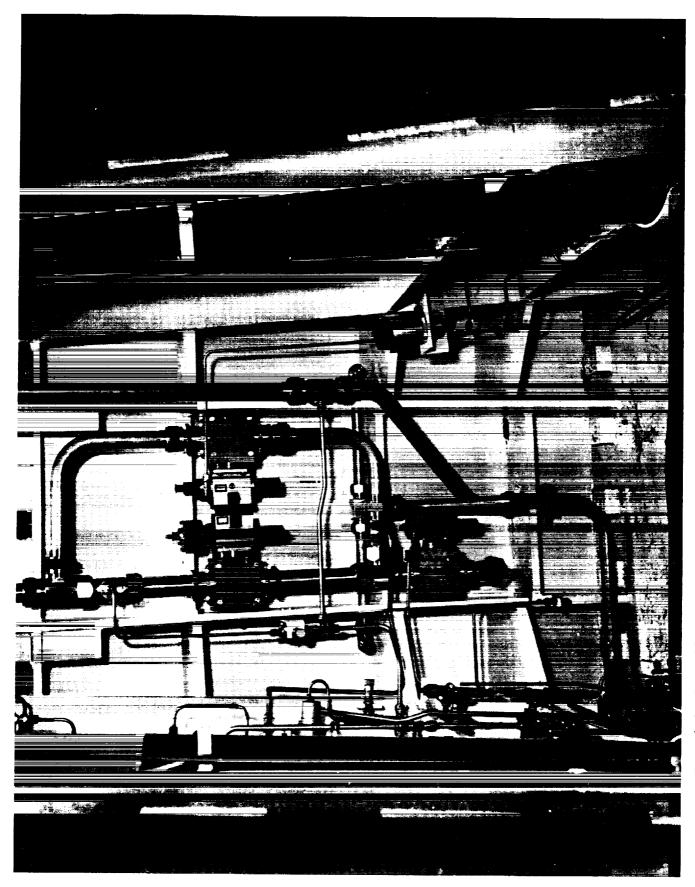
The following references give installation details for the actuating system:



Installation of cylinder supply valve, hydraulic supply valve, and filter Fig. 4-1

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4-2



Installation of hydraulic control valve #1, control by-pass valve, and gravity drain shut-off valve. Fig. 4-2

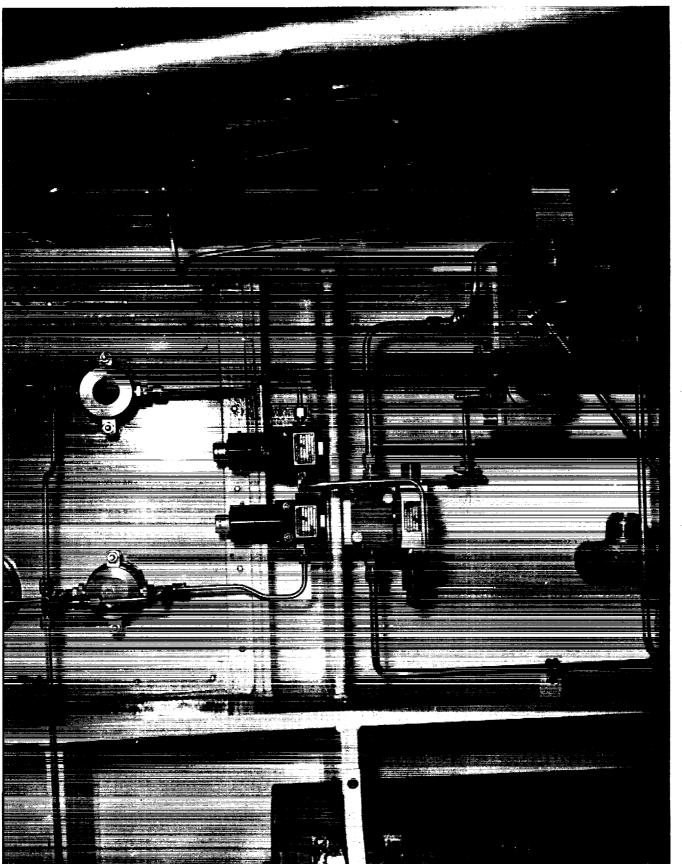


Fig. 4-3 Installation of pressure valves, regulators, gauges, and four-way control valve.

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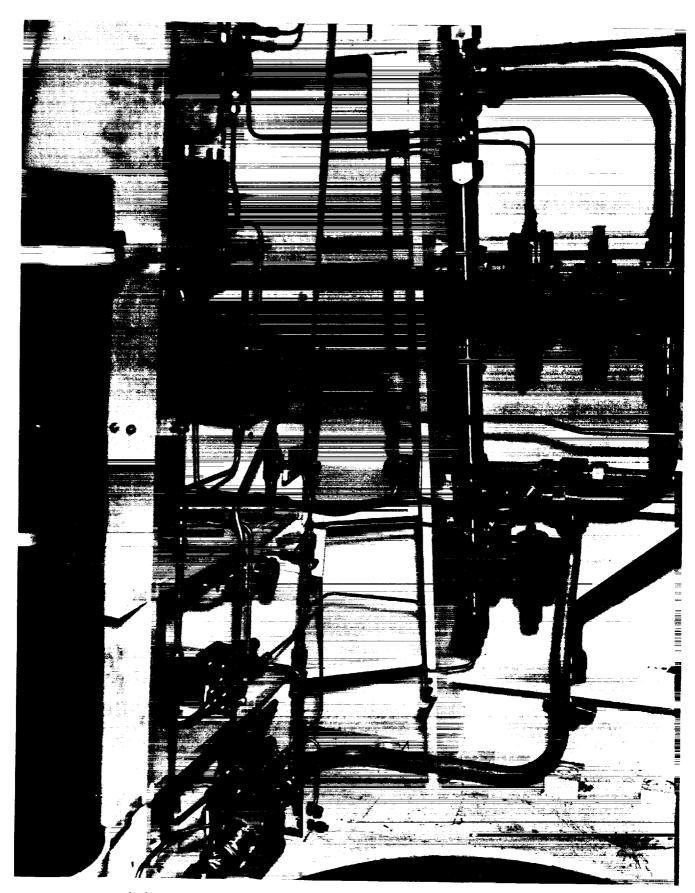


Fig. 4-4 Installation of accumulator, hydraulic return valve #2, control by-pass valve, and gravity drain shut-off valve

- Refer to Drawing No. 75M05857 for installation specifications.
- b. Install and adjust cam valve and cam in accordance with Drawing No. J75M11798.
- c. Test for leakage and clean in accordance with Ordnance Drawing No. 10425040.

4-2 HOOD INSTALLATIONS

The hood actuating system is completely hydraulically operated and is self-contained. The electrical system is not involved in the hood operation except for indicator lights. The pneumatic system for the hood is limited to operation of the ball locks and charging of the system. The hood hydraulic system tubing, valves, gauges, and slave units are installed entirely within the mast arm structure. The master units are installed onto extensions of the top plate of the base and are protected by removable covers.

A. MASTER ACTUATORS (DWG. NO. 75M11997). The hood master actuators are of the rack and pinion type. This type rotary actuator is designed to either drive a shaft when pressure is provided or to provide pressure when the shaft is driven.

The master actuators are installed upon supports that extend from the sides of the Tail Service Mast base. The shafts of the actuators are attached directly to a torque transfer lever which is driven by the rotation of the mast arm.

The actuators are capable of 80° rotation. Since the mast will rotate only 70° the actuator shafts are positioned with a 5° margin on both ends of the stroke. This will allow for tolerance build-up and will provide cushion on both extremes of travel.

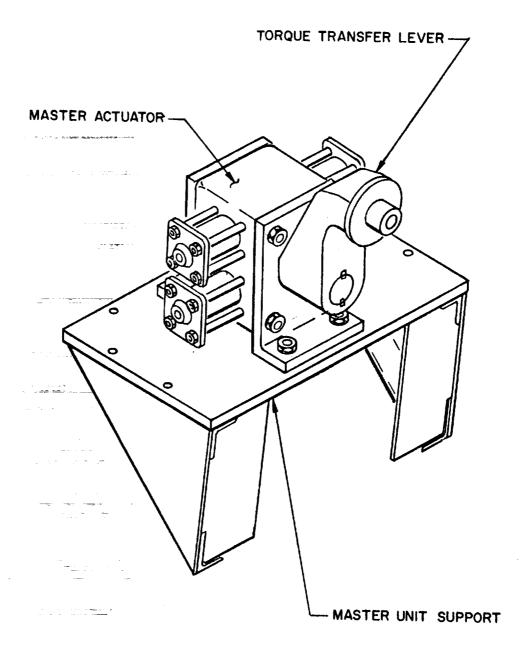


Fig. 4-5 Installation of master actuators on supports

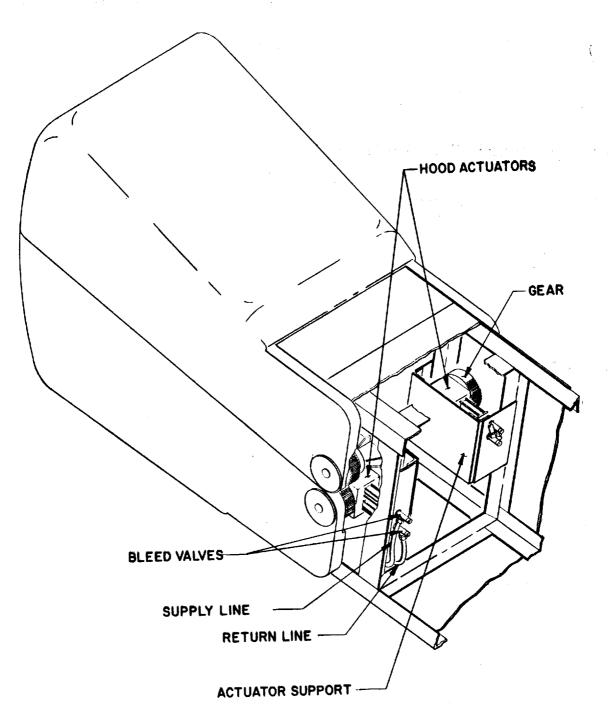


Fig. 4-6 Hood showing installation of slave actuators and supports

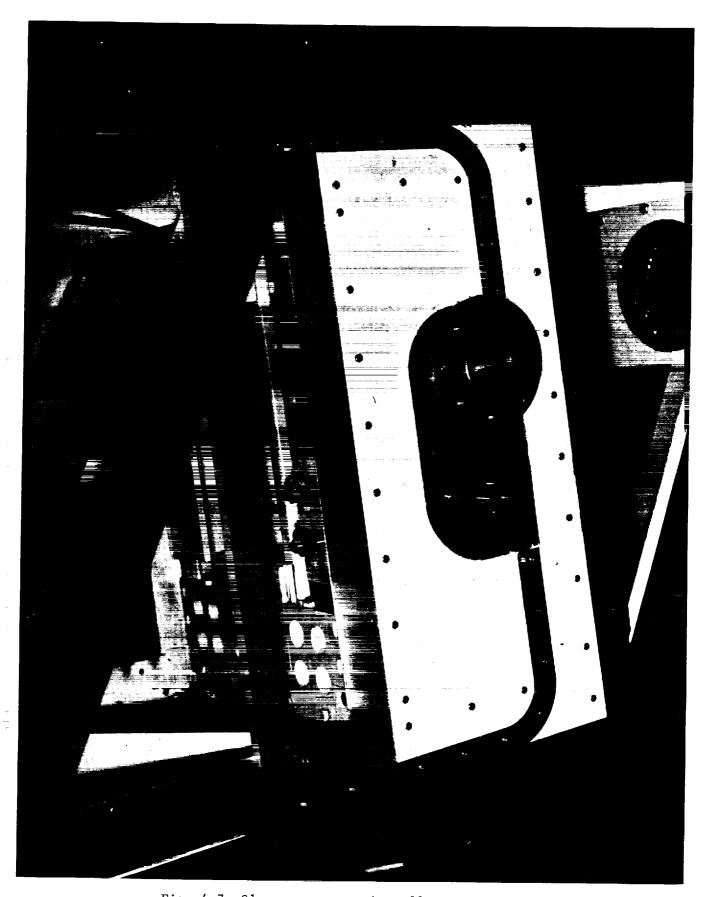


Fig. 4-7 Slave actuators installed in mast arm

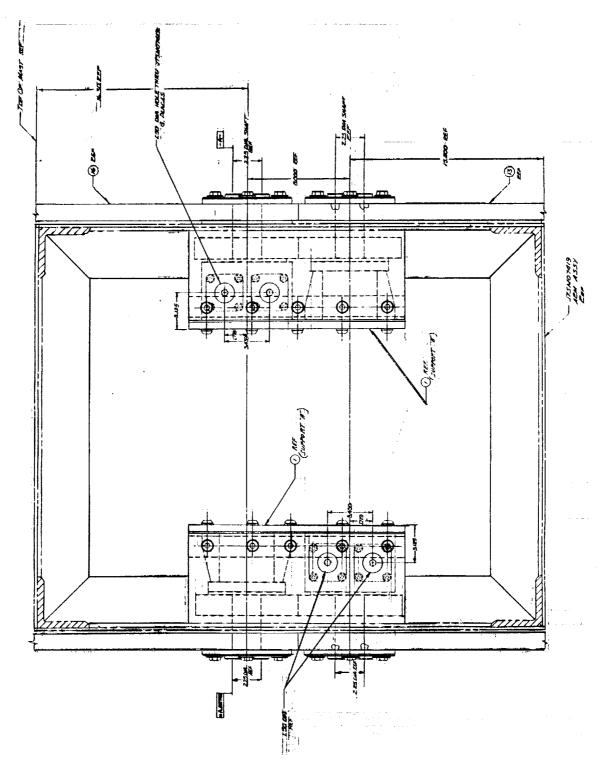
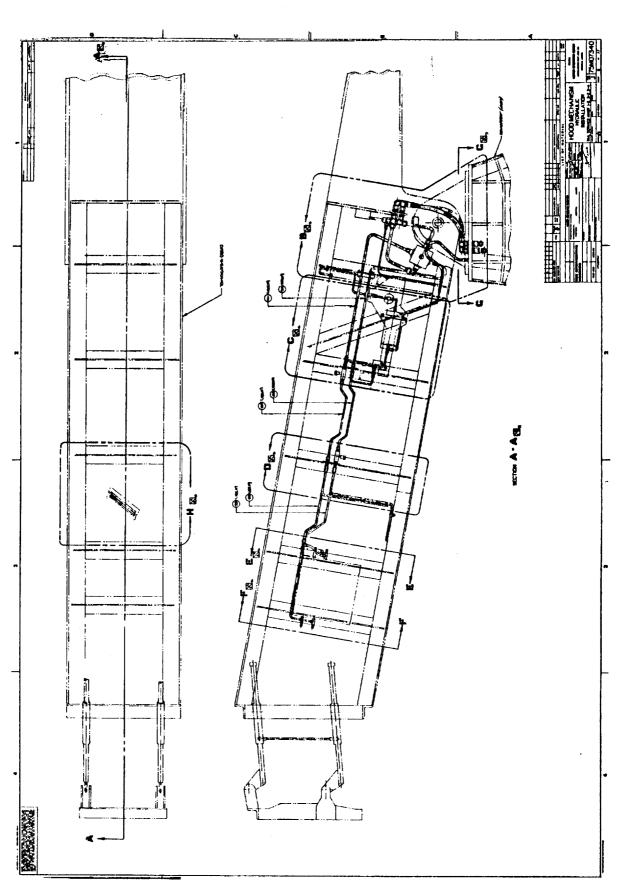


Fig. 4-8 Location of slave actuators in Mast Arm cross section

4-10



g. 4.9 Hood mechanism hydraulic installation

- B. SLAVE ACTUATORS. The hood slave actuators are identical to the master actuators in operating principle. Pressure is provided from the master actuators to drive a shaft which is attached to either side of the hood. The slave actuators are installed in the forward section of the mast arm. Supports are provided during construction of the arm. Each actuator is installed with a gear driven free shaft which is attached directly to the opposite half of the hood. The slave actuators are capable of 90° rotation and are oriented such that they will bottom out when the hood is open. The 85° rotation of the hood for closure will leave a 5° margin for safety and cushioning.
- C. HOOD HALVES. The hood halves are installed over the drive shaft of the slave actuators and over the free shafts by removing the hood detachment plugs. The hood detachment plugs are fastened to a steel insert located at the attachment points of each hood half. The hood is oriented on the slave actuators so that 85° rotation will completely close the hood.

4-3 SERVICE LINES INSTALLATION

The primary objective of the Tail Service Mast is to contain the services lines and to afford protection for them during lift-off of the Saturn V vehicle. The main difference in the three masts is the type service lines carried. This section outlines the three Tail Service Masts and the service lines carried in each.

- A. Tail Service Mast 1-2 service lines.
 - 1. 6" Fuel fill and drain
 - 2. 3/4" Helium bottle fill
 - 3. 3/4" Fuel tank pre-pressure
 - 4. 2" Hydraulic supply

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- 5. 2" Hydraulic return
- 6. 1" Thrust chamber pre-fill
- 7. 1/4" Pressure switch fuel tank
- 8. 1/4" Pressure switch, He, HP & LP switch (Automatic Checkout)
- 9. 1/4" Dummy plug (spare)
- 10. 1/4" Mast pneumatic retraction
- 11. 1/4" Omit
- 12. 1/4" N/A reserved for micro switch
- 13. 40SS Main power from GSE
- 14. 40SS Range safety system
- 15. 40SS Power regulation on/off command
- 16. 40SS Lox vent, He system & sequence & control system
- 17. 40SS Lox fill & drain GN_2 system and rough combustion
- 18. 40SS Engines 1 & 4 ignition and monitor
- 19. 40SS Prevalves, engine cut-off and thrust o.k.
- 20. 40SS Electrical Spare
- 21. 40SS Electrical
- 22. 1 1/2" Hydraulic return
- 23. 1/2" Hydraulic pressure 2200 psi
- 24. 1/4" 50 psi GN_2 purge
- 25. 3/8" 3000 psi GN_2 hydraulic pressure
- 26. 40SS Electrical
- 27. 1/4" Lock mechanism disconnect (umbilical)
- 28. 1/4" Mast hood lock mechanism
- 29. Lock mechanism accumulator supply
- 30. 3/8" 6" Fuel line purge

- B. Tail Service Mast 3-2 service lines.
 - 1. (Res for 6" Lox drain)
 - 2. 7" Environmental purge control
 - 3. 7" Environmental purge control
 - 4. 1/4" Sensor coupling for service mast pneu retract
 - 5. 1" Gas generator fuel injector purge
 - 6. 3/4" Lox bubbling (cond engine pre-ignition)
 - 7. 1/4" Lox bubbling emergency after shut down
 - 8. 3/8" Fuel bubbling
 - 9. 1/4" Valve control pressure (Lox fill & drain)
 - 10. 1/4" Valve control pressure (Lox fill & drain)
 - 11. 1/4" Sensor engine cutoff, lox pressure (automatic checkout)
 - 12. 3/8" Dummy plug (spare) reserved for engine pre-valve coupling
 - 13. 1/4" N/A reserved for micro switch to indicate plate separation
 - 14. 3/8" Dummy plug (spare) reserved for engine pre-valve coupling
 - 15. I" Environmental purge to battery container
 - 16. 1/2" 2,200 psi hydraulic
 - 17. #40 Electrical
 - 18. #40 Electrical
 - 19. 3/8" 3,000 psi GN₂ hydraulic pressure
 - 20. 1/4" Lock mechanism disconnect (umbilical)
 - 21. 1/4" Mast hood lock mechanism
 - 22. 1/4" 50 psi GN_2 purge
 - 23. 1 1/2" Hydraulic return
 - 24. 1/4" Lock mechanism accumulator supply

- C. Tail Service Mast 3-4 service lines
 - 1. 6" Lox fill & drain
 - 3/4" Lox tank pre-pressure
 - 1/2" Control pressure bottle fill
 - 4. 1/4" Pressure switch regulator control pressure (LP)
 - 5. 1/4" Automatic checkout, HP switch control & purge supply
 - 6. 1 3/4" Lox dome & GG Lox purge
 - 7. 3/8" Purge supply (LP) automatic checkout
 - 8. 1/4" Valve control pressure (fuel fill & drain)
 - 9. 1/4" Dummy plug (spare)
 - 10. 1/4" Valve control pressure (Lox drain)
 - 11. 1/4" Reserved for mast pneumatic retraction
 - 12. 1/4" N/A reserved for micro switch
 - 13. #40 Engine IGN #2 & #3 and monitor
 - 14. #40 Heater system
 - 15. #40 Telemeter monitor and DDAS (coax)
 - 16. #40 Engine #5, ignition and monitors
 - 17. #40 Measuring rack, selectors and measurements
 - 18. #40 Instrumentation control 400 cps and monitor
 - 19. #40 Electrical (Spare)
 - 20. #40 Electrical (Spare)
 - 21. #40 Electrical
 - 22. 3/8" 3,000 psi GN₂ hydraulic pressure
 - 23. 1 1/2" Hydraulic return
 - 24. 1/2" 2,200 psi hydraulic
 - 25. #40 Electrical
 - 26. 1/4" Lock mechanism disconnect (umbilical)
 - 27. 1/4" Mast hood lock mechanism
 - 28. 1/4" 50 psi GN₂ purge

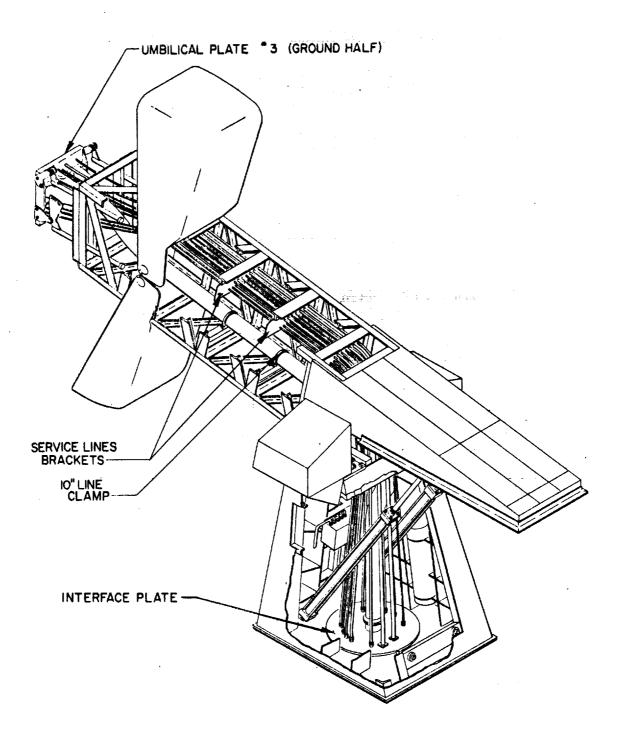


Fig. 4-10 Service lines installation

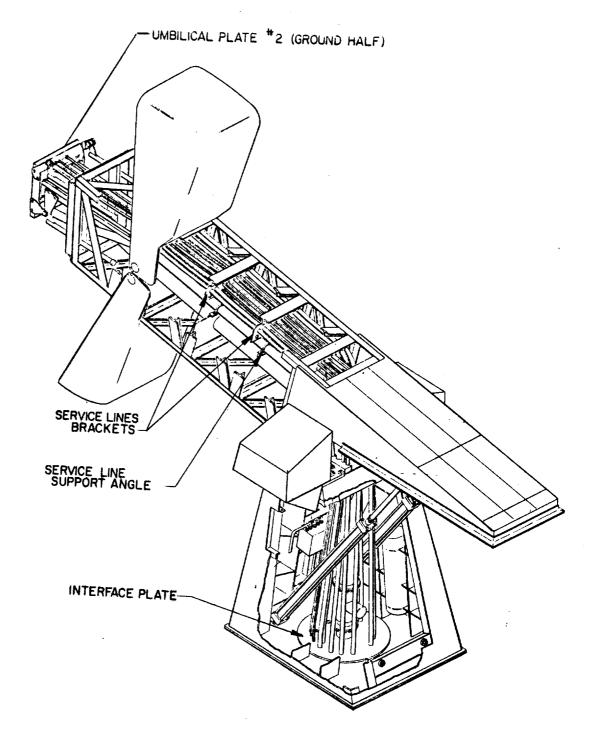


Fig. 4-11 Service lines installation

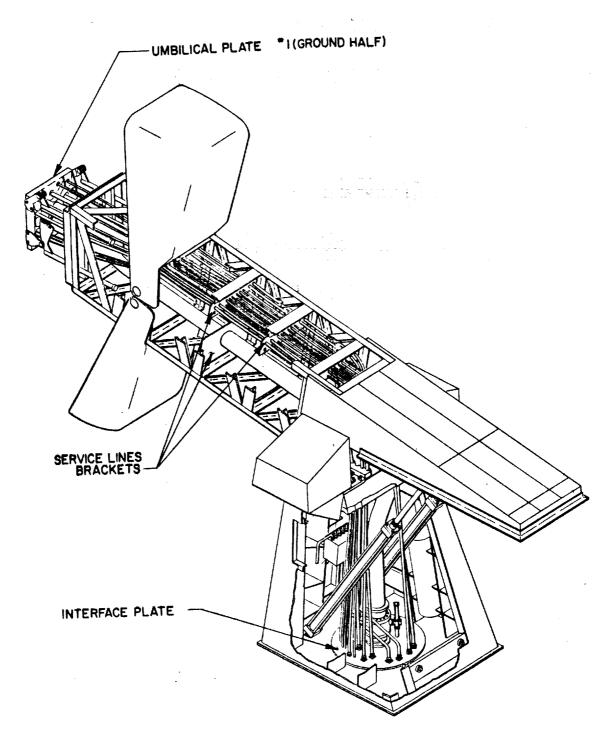


Fig. 4-12 Service lines installation

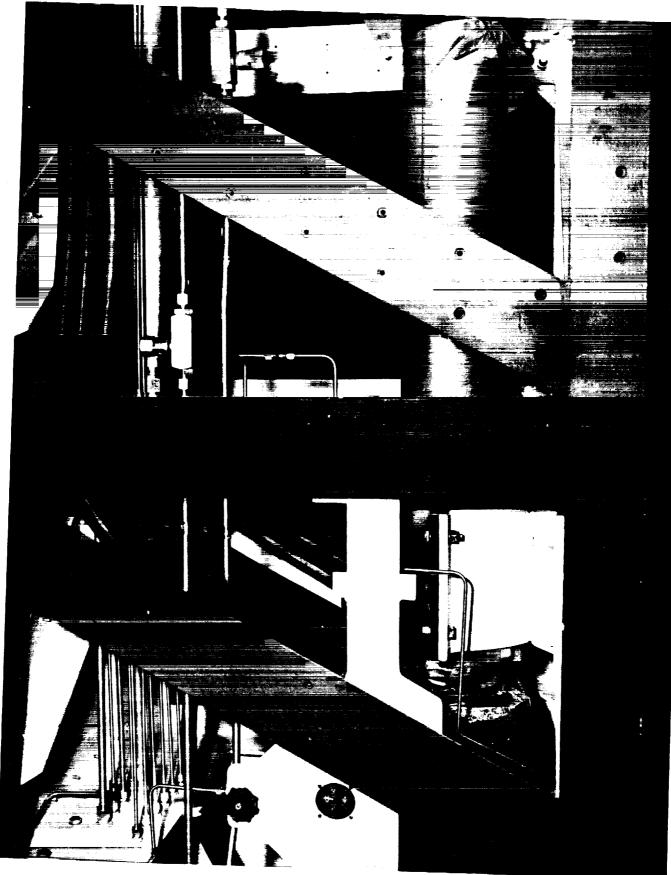
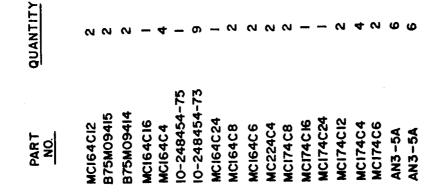
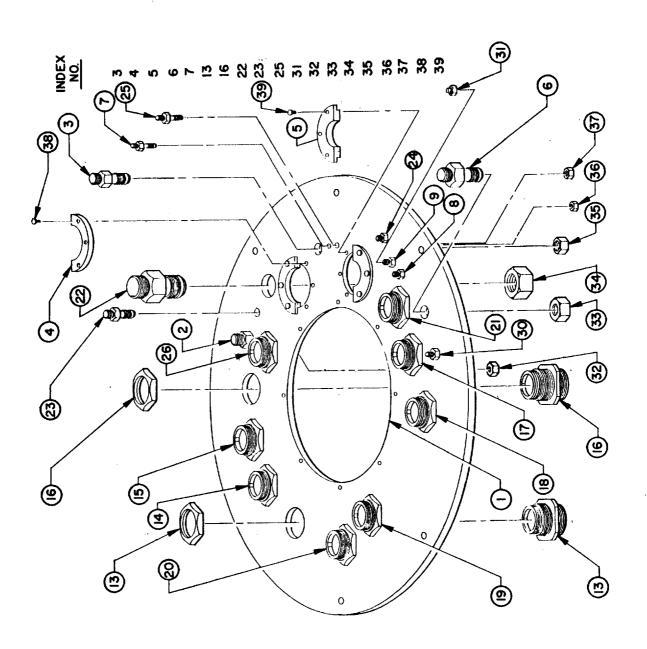
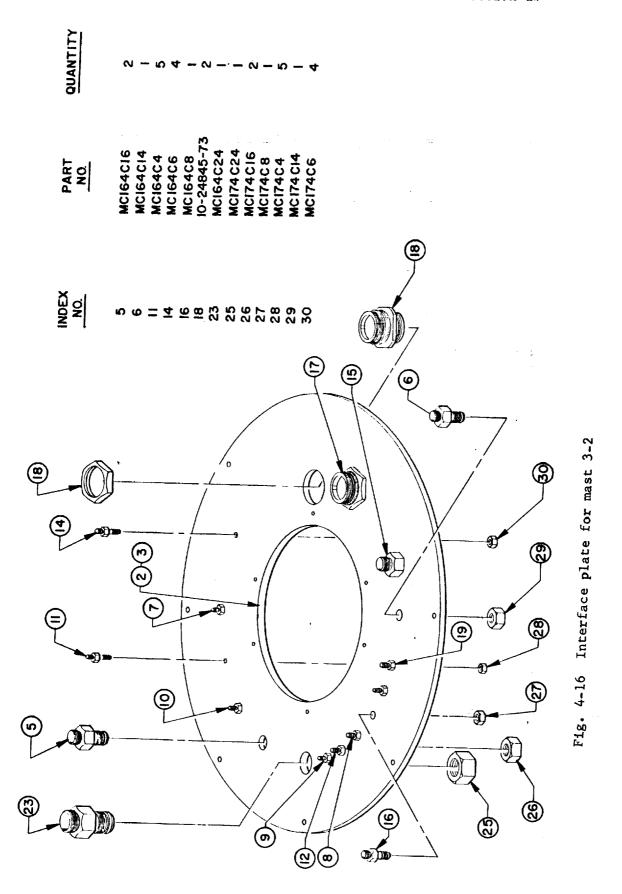
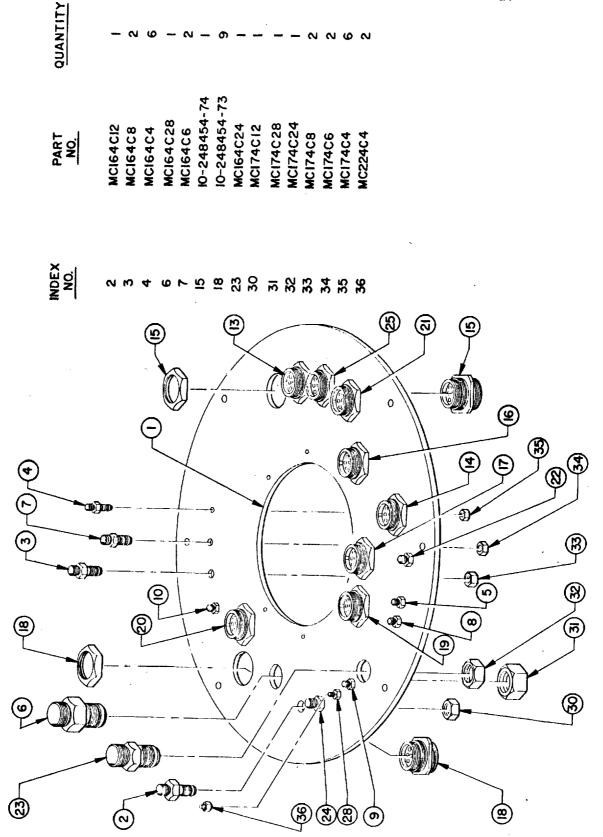


Fig. 4-14 Service lines installation showing hood control orifices.









4-23

Fig. 4-17 Interface plate for mast 3-4

4-4 TAIL SERVICE MAST HANDLING AND TRANSPORTATION

This section outlines the handling procedure for the Tail Service Mast.

Lifting lugs have been provided as a part of the mast structure and the mast should be handled utilizing these lugs. Lifting beams as well as wire rope have been called out as a part of the handling equipment. All handling materials have been checked stress-wise and are sufficient to handle loads in excess of requirements.

The lifting lugs provided on the base are an integral part of the base while those provided on the arm structure are of a removable type. The mast may be handled by these lifting lugs or it may be placed upon the handling frame for convenience. The handling frame is designed to fit upon a low-bed truck for transportation of the Tail Service Mast.

The Tail Service Mast may be transported complete with pneumatic, electrical and hydraulic installations and all service lines which are terminated with fittings for connection to the interface plate. The interface plate must be shipped as a separate unit.

The steps outlined in this section should be followed for handling and transporting of the Tail Service Mast.



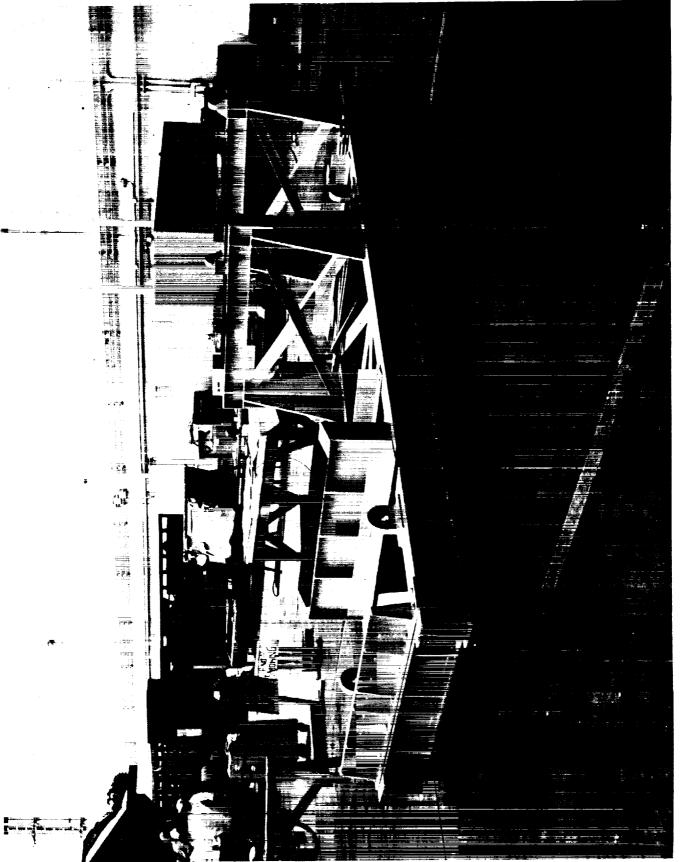
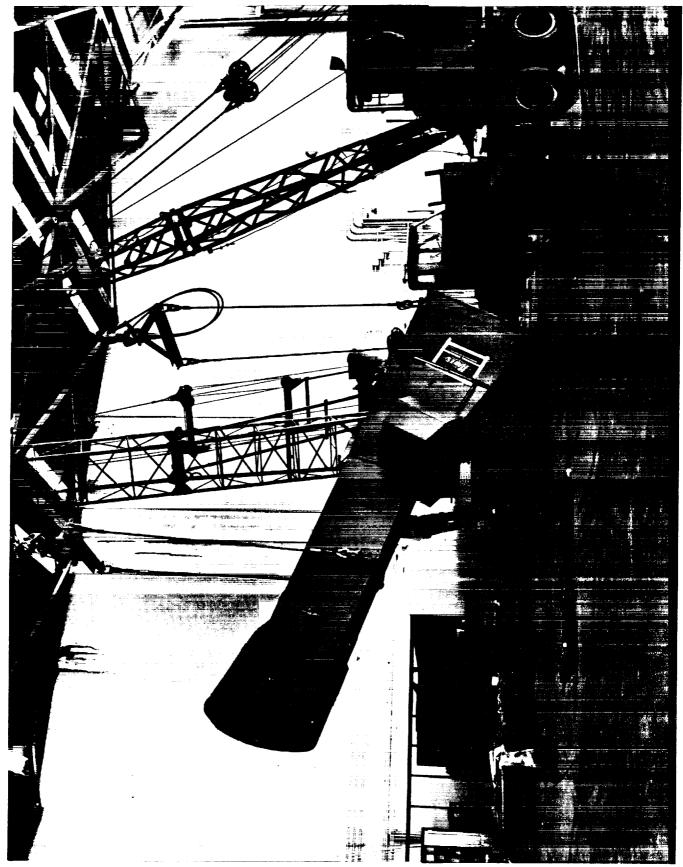
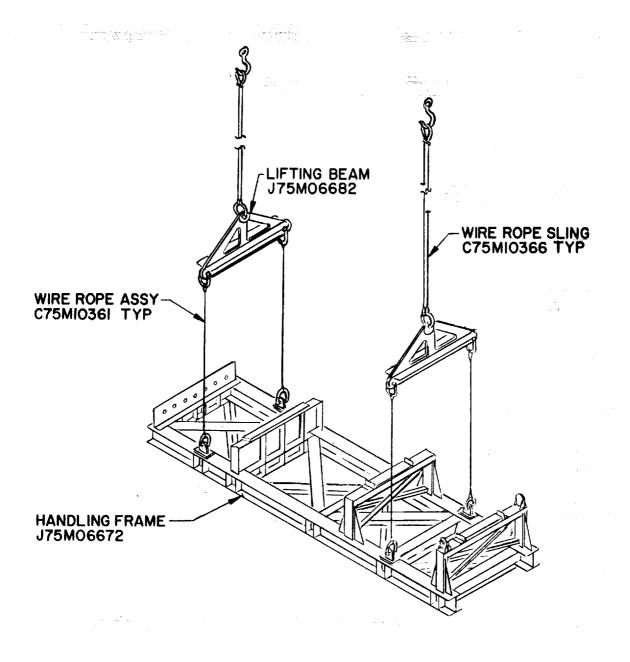


Fig. 4-19 Tail Service Mast handling frame

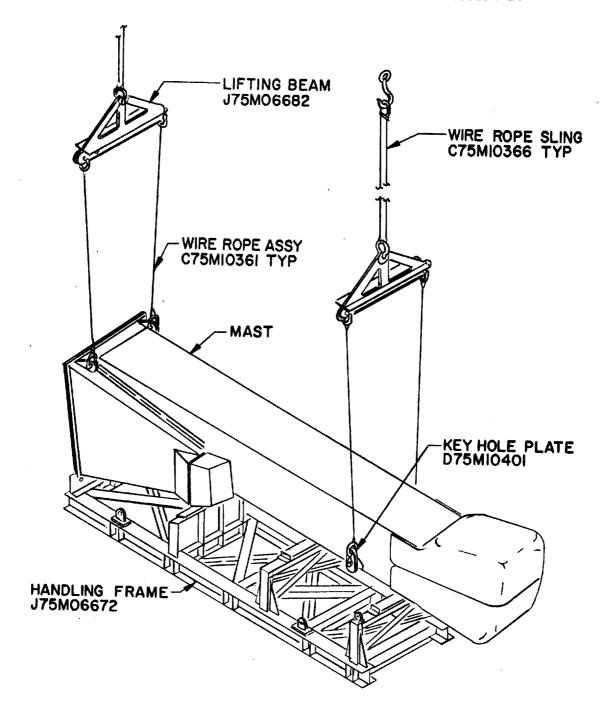
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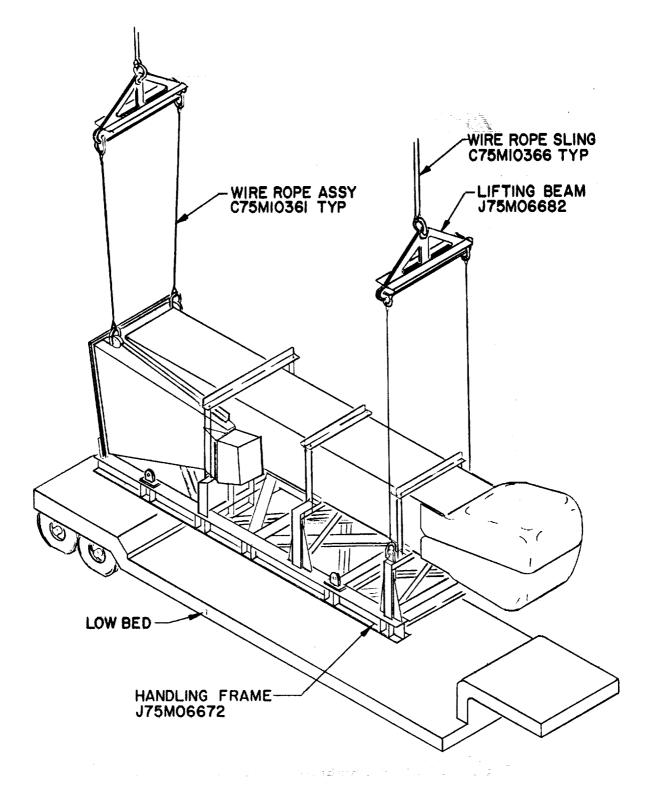
I. LIFT HANDLING FRAME & MOVE TO DESIRED LOCATION

Fig. 4-21 Handling sequence



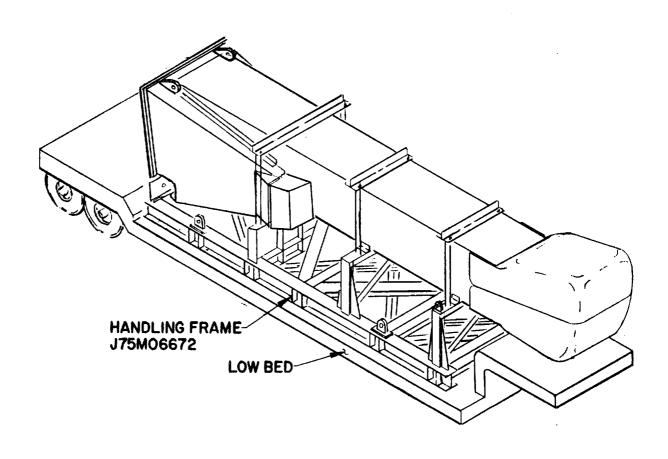
2. LIFT MAST BY REVERSING STEPS 6 & 7, THEN LOWER MAST TO REST ON HANDLING FRAME

Fig. 4-22 Handling sequence



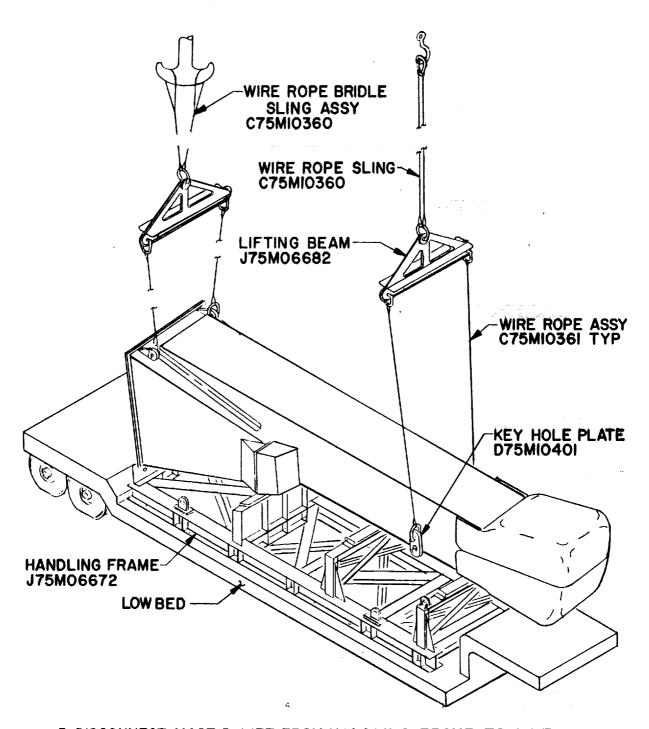
3. LIFT MAST & HANDLING FRAME AS A UNIT & PLACE ON LOW BED

Fig. 4-23 Handling sequence



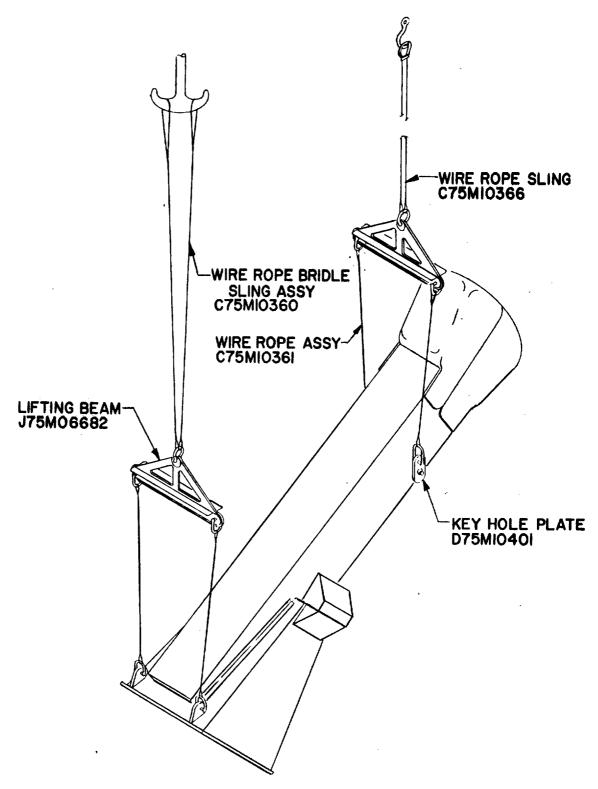
4. FASTEN HANDLING FRAME TO LOW BED & TRANSPORT TO LOCATION

Fig. 4-24 Handling sequence



5. DISCONNECT MAST & LIFT FROM HANDLING FRAME TO L-UT

Fig. 4-25 Handling sequence



6. ROTATE FROM HORIZONTAL TO VERTICAL POSITION

Fig. 4-26 Handling sequence

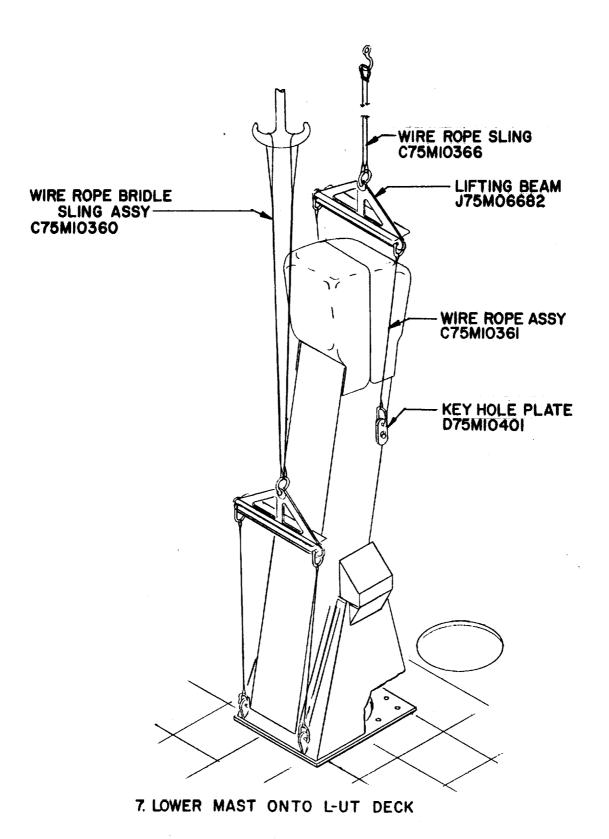
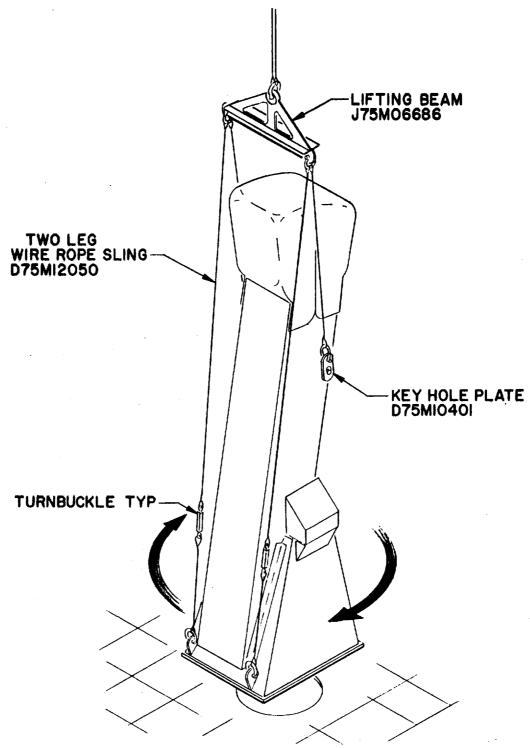


Fig. 4-27 Handling sequence



8. LIFT MAST, ROTATE & POSITION ON L-UT DECK

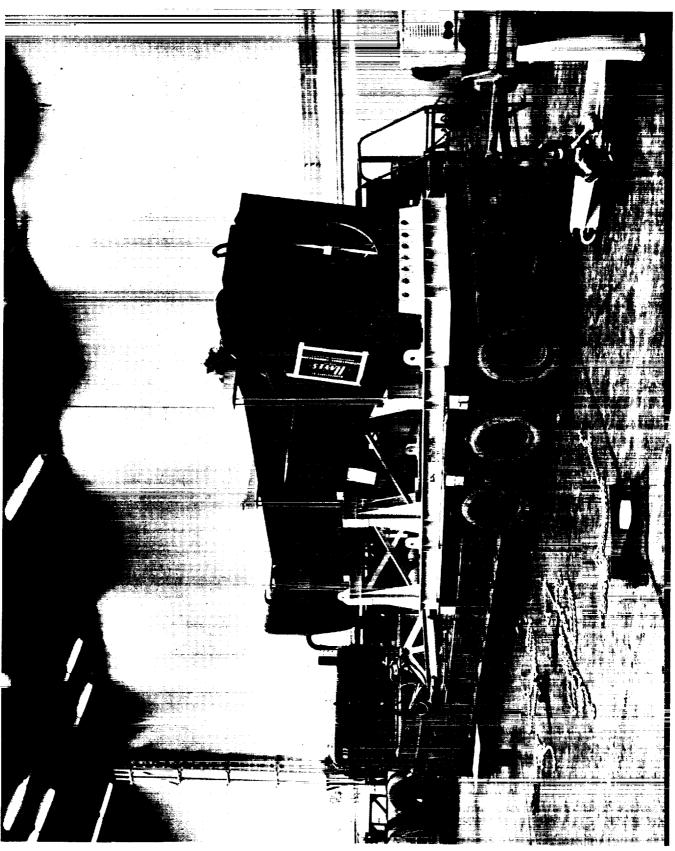
Fig. 4-28 Handling sequence



Fig. 4-29 Tail Service Mast with frame on low bed

4-36

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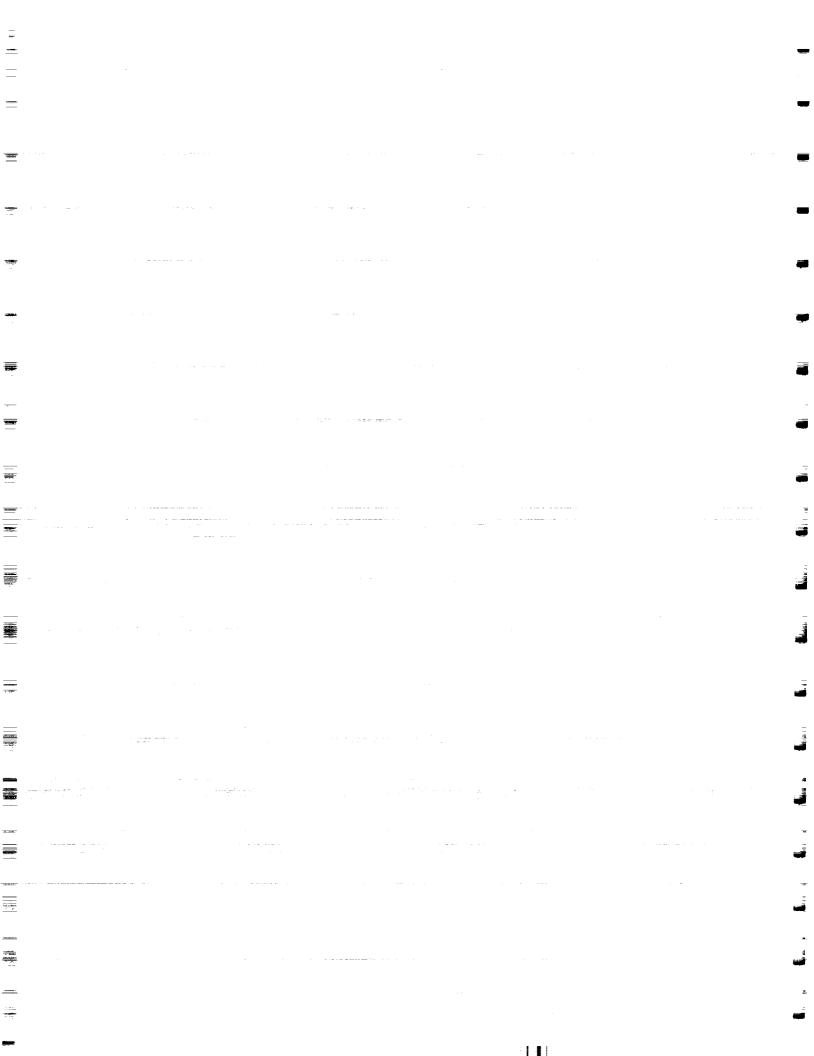
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SECTION TAIL SERVICE MAST PREPARATION

5-I TAIL SERVICE MAST HYD SYSTEM

5-2 PROTECTIVE HOOD HYD SYSTEM

5-3 ELECTRICAL SYSTEM



SECTION V TAIL SERVICE MAST PREPARATION

5-1 MAST HYDRAULIC SYSTEM

A. TEST SET CONNECTION

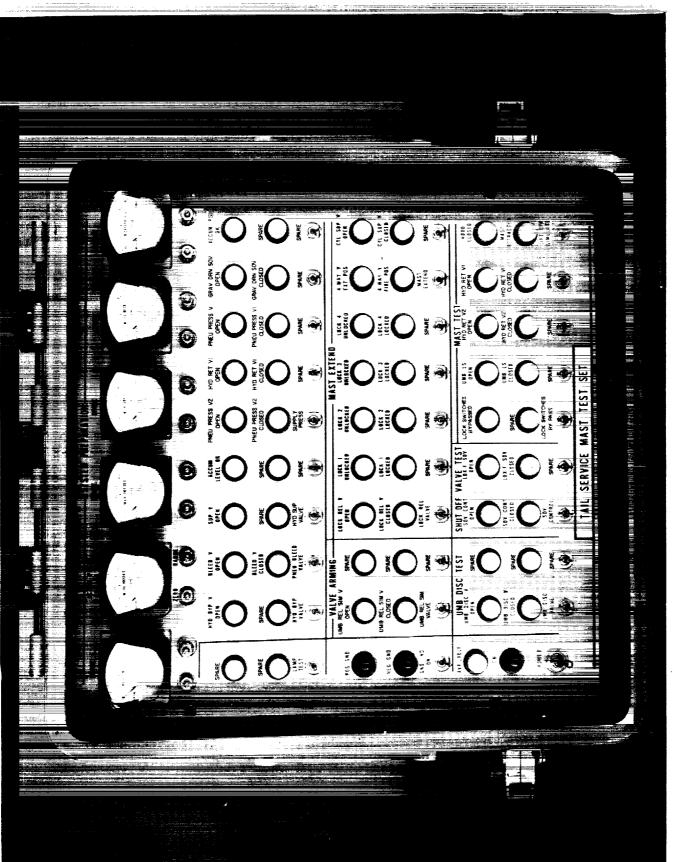
- 1. Remove cable assembly D75M09062-35, replace with cable assembly D75M09109-4 from test set 7601.
- 2. Remove cable assembly D75M09062-36, replace with cable assembly D75M09109-5 from test set 7601.

B. TEST SET CHECKOUT (Reference Figure 5-1)

- 1. POWER AVAILABLE light should be ON.
- 2. All switches on the test set in the OFF (down) position.
- 3. POWER switch in ON (up) position. Indicator light on.
- 4. Place GND IND switch in ON (up) position. POS GND & NEG GND lights should have equal brightness. Return GND IND switch to OFF (down) position.
- 5. Place LAMP TEST switch to ON (up) position. All lamps should illuminate. Return switch to OFF (down) position.
- C. FILLING AND BLEEDING (REF. SCHEMATIC 75M12375)

NOTE: Base hydraulic system will be bled with mast in retracted (vertical) position.

- 1. Connect the four 1/4 inch flex hoses to the bleed valves at the top and bottom of each hydraulic cylinder, and connect the four bleed valves to the flex hoses.
- 2. CLOSE the bleed valve on each flex hose and open the bleed valve at each cylinder port.
- 3. Turn on the 2000 PSI pneumatic supply.
- 4. OPEN flow restrictor valves #1 (AL), #2 (AM), #3 (AN), and #4 (AP) to full open position.
- 5. Place test set power on in ON position. (Test Set)
- 6. CLOSE umbilical release simulator valve (AC). (Test Set)
- 7. OPEN pressure supply valve #2 (K). (Test Set)



ig. 5-1 Tail Service Mast test set showing panel lights

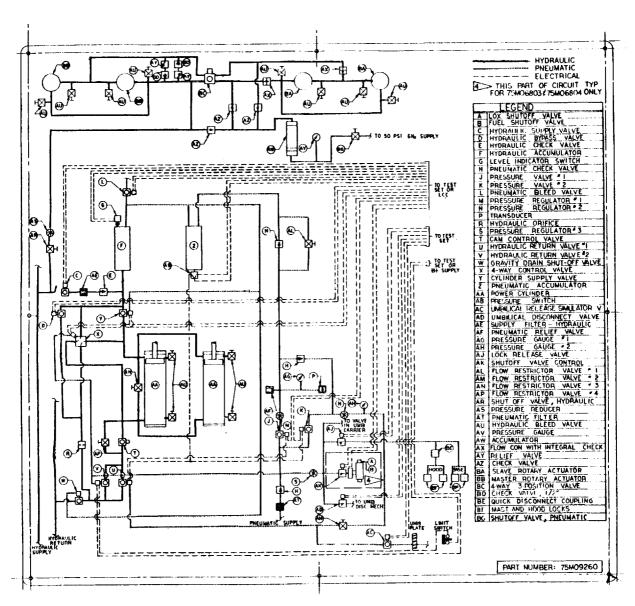


Fig. 5-2. Tail Service Mast Nameplate Schematic

- 8. Adjust mast pressure regulator #2 to 750 PSI.
 - a. Pressure supply valve #2 (K) will open. (Test Set)
 - b. Hydraulic return valve #1 (0) will close. (Test Set)
 - c. Pressure supply valve #1 (J) will open. (Test Set)
- 9. Adjust mast pressure regulator #1 to 2000 PSI.
 - a. Pneumatic accumulator PSI OK light will illuminate. (Test Set)
 - b. Pressure supply valves #1 (J) and #2 (K) will close. (Test Set)
 - c. Gravity drain valve (W) will open. (Test Set)
- 10. Return pressure supply valve #2 switch to DOWN position. (Test Set)
- 11. Start hydraulic pump and adjust output pressure to 200 PSI.
- 12. OPEN hydraulic supply valve (C). (Test Set)
- 13. CLOSE flow restrictor valve #3 (AN) in mast base.
- 14. OPEN bleed valves on top of cylinders.
 - a. Leave bleed valves open until air is depleted.
- 15. CLOSE bleed valves on top of cylinders.
- 16. OPEN flow restrictor valve #3 (AN) in mast base.
- 17. OPEN bleed valves at bottom of cylinders.
- 18. After one minute, open hydraulic bypass valve (D). (Test Set)
- 19. After five minutes, close hydraulic bypass valve (D). (Test Set)
- 20. CLOSE flow restrictor valve #3 (AN) in mast base.
- 21. CLOSE manual hydraulic return hand valve.
- 22. OPEN lock release valve (AC. (Test Set)
- 23. Place mast extend switch in UP position. (Test Set)
 - a. Four-way control valve (X) will open. (Test Set)
 - b. Cylinder supply valve (Y) will close. (Test Set)

- 24. When air is bled from bottom of cylinders, CLOSE bleed valves at bottom of cylinders.
- 25. OPEN flow restirctor valve #3 (AN) in mast base.
- 26. After five minutes, place mast extend switch in DOWN position. (Test Set)
 - a. Four-way control valve (X) will return to fire position (CLOSED). (Test Set)
 - b. Cylinder supply valve (Y) will open. (Test Set)
- 27. CLOSE flow restrictor valve #2 (AM) in mast base.
- 28. OPEN manual hydraulic return hand valve.
- 29. OPEN umbilical release simulator valve (AC). (Test Set)
 - a. Hydraulic return valve #1 (U) will open. (Test Set)
- 30. After five minutes, CLOSE flow restrictor valve #4 (AP).
- 31. Increase hydraulic pump output pressure to 750 PSI.
- 32. After five minutes, CLOSE umbilical release simulator valve (AC). (Test Set)
- 33. OPEN flow restrictor valve #2 (AM).
- 34. Place lift-off simulator switch in the UP (extend) position. (Test Set)
 - a. Hydraulic return valves #1 (U) and 3 (V) will open. (Test Set)
- 35. Continue running hydraulic pump for two minutes.
- 36. CLOSE manual hydraulic return hand valve.
- 37. CLOSE hydraulic supply valve (C). (Test Set)
- 38. STOP hydraulic pump.
- 39. CLOSE all hydraulic bleed valves.
- 40. Return all test set switches to the DOWN position. (Test Set)
- 41. CLOSE 2000 PSI pneumatic supply pressure to mast.

- 42. OPEN pneumatic bleed valve (L) and leave open until all air is depleted from base pneumatic system. (Test Set)
- 43. CLOSE pneumatic bleed valve (L). (Test Set
- 44. Return test set power switch to OFF position. (Test Set)

 Base hydraulic system is bled.
- 45. Mast may now be charged for extension, refer to Section 7-2.

5-2 HOOD HYDRAULIC SYSTEM

- A. TEST SET CONNECTION
 - 1. Connect test set 7601 in accordance with section 5-1A & B.
- B. FILLING AND BLEEDING (REF. SCHEMATIC 75M12376)

NOTE: Hood system may be bled with mast in extended (HORIZONTAL) position. Refer to section 7-3 for mast extension.

- 1. After mast is in extended postion, connect safety cable assemblies between forward base lugs and arm lifting lugs.
- 2. After cable assemblies are in place, OPEN pneumatic bleed valve (L) (Test Set).
- 3. The 50 PSI pneumatic supply line (Ser. Line #28) is to be connected to valve (BG).
- 4. OPEN valve (BG). This will charge the 58 cu. in. accumulator located in the arm assembly as shown on gauge (AV).
- 5. CLOSE valve (BG).
- 6. OPEN the hydraulic hand valve (Hood Shutoff Valve, AR) located in the mast base (Ref. 75M17375).
- 7. Start hydraulic pump (pump is to be set at 200 PSI, 5 GPM output). This allows oil to flow through a pressure reducer and enter the hood system at 100 PSI.
- 8. OPEN each bleed valve (AU) located in the ports of each actuator. Keep open until fluid is free of air.
- 9. CLOSE bleed valves, bleed procedure should be repeated if sponginess is noted during mast operation.

- 10. CLOSE hydraulic hand valve (AR) in mast base. System is now charged and gauge in arm assembly should read 100 PSI.
- 11. Make final adjustments of flow control valve (AX) only after system has been operated in conjunction with the main hydraulic system for the mast.
- 12. The mast is now ready to charge for retraction, refer to section 7-4 for charging prior to retraction or control system may be de-energized and test panel secured refer to section 7-6 for securing procedure.

5-3 ELECTRICAL SYSTEM

The electrical system is inherent to the Tail Service Mast and the only preparation other than connections is the connection of the test set.

Test Set 7601 is a separately contained unit and the only preparation necessary is proper connection.

This section outlines the several steps necessary to ready the test set for operation.

- 1. Insure that cables from hydraulic and pneumatic components are connected to the distributor.
- 2. Remove cable assembly D75M09062-35 (J1) from distributor and replace with cable assembly D75M09109-4 (7601W1) from test set.
- 3. Remove cable assembly D75M09062-36 (J2) from distributor and replace with cable assembly D75M09109-5 (7601W2) from test set.
- 4. Connect Test Set 7601 to 28VDC power supply with cable assembly (7601W3).

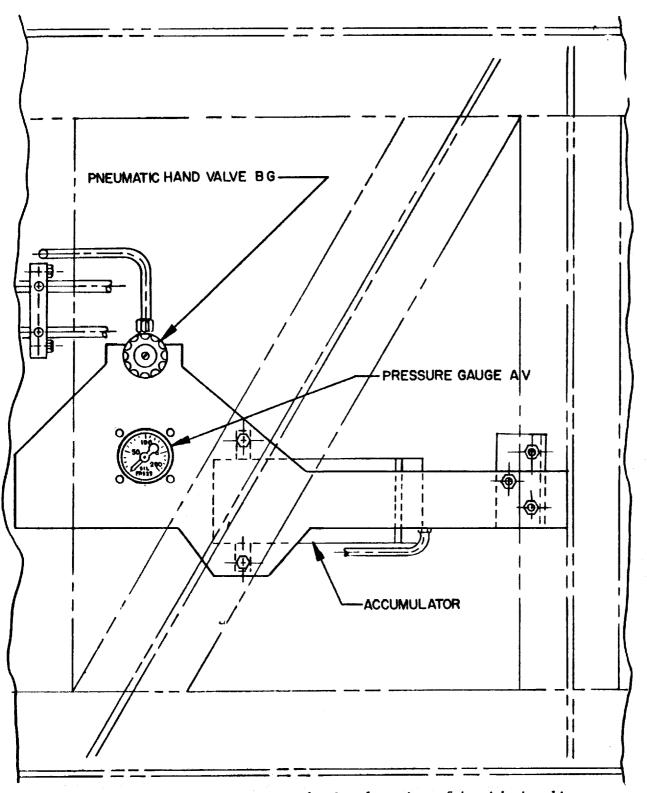


Fig 5-3 Tail Service Mast arm showing location of hood hydraulic system pressure gauge and hand valve.

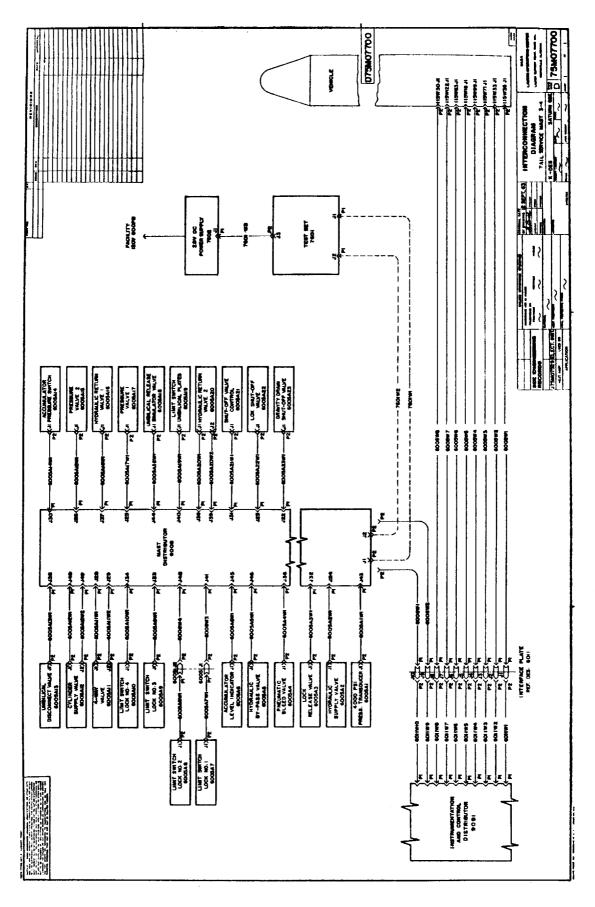
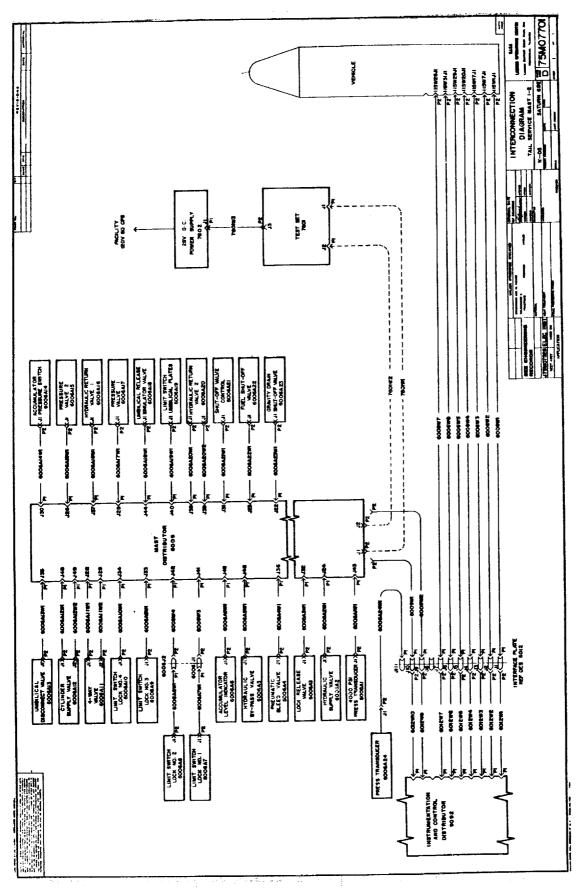


Fig. 5-4 Electrical Interconnection Diagram for TSM 3-4



'ig. 5-5 Electrical Interconnection Diagram for TSM 1-2

TIL

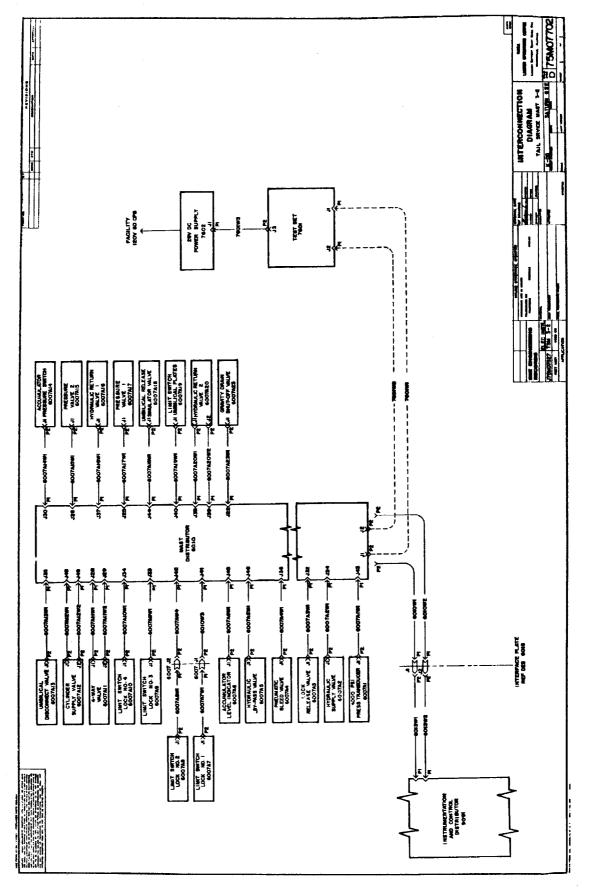


Fig. 5-6 Electrical Interconnection Diagram for TSM 3-2

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SECTION VI TAIL SERVICE MAST CHECKOUT

6-1 ELECTRICAL

6-2 TAIL SERVICE MAST HYD SYSTEM

6-3 PROTECTIVE HOOD

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SECTION VI TAIL SERVICE MAST CHECKOUT

6-1 ELECTRICAL CHECKOUT

Electrical checkout of the Tail Service Mast consist mainly of checking the test set in operation.

Once the test set is connected to the mast several features of the mast may be checked electrically from the test set.

- 1. After the test set is connected to the power supply turn on the test set and adjust the power supply to 28V.
- 2. Place the GRD IND switch in the ON position. The POS GND and NEG GND lamps should have equal brilliance.
- 3. Test all lamps by placing LAMP TEST switch in ON position. Return switch to OFF position. All lamps except those indicating normal position of valves will go out.

Test set is ready for operation and my be used to operate the Tail Service

Mast or check any individual component for proper position by a system of

ON-OFF lights.

6-2 TAIL SERVICE MAST HYDRAULIC SYSTEM

In the event there has been a considerable time delay between the preparation of the Tail Service Mast and the actual operation of the mast there is provided a means for draining and recharging the hydraulic accumulator to insure readiness. A bypass valve is located between the hydraulic supply and return lines to facilitate draining. The accumulator is then re-charged using normal procedure.

6-3 PROTECTIVE HOOD

Once the hood hydraulic system is prepared for operation, no further action is necessary. The pressure gauge located near the handvalve in the arm should read approximately 100 psi.

After a considerable time delay the hood hydraulic system should be checked for leaks and only other obvious discrepancies.

SECTION VII TAIL SERVICE MAST OPERATION

7-I TEST PREPARATION

7-2 MAST CHARGING PRIOR TO EXTENSION

7-3 MAST ARM EXTENSION

7-4 MAST CHARGING PRIOR TO RETRACTION

7-5 MAST ARM RETRACTION

7-6 TEST SET SECURING AND
CONTROL SYSTEM DE-ENERGIZING

7-7 RELATED VEHICLE OPERATION

11.15 TELETER CONTROL CONTRO

SECTION VII TAIL SERVICE MAST OPERATION

7-1 TEST PREPARATION

A. REQUIREMENTS

- 28 VDC power supply
- 2. 2000 PSI min GN₂ supply
- 3. 2000 PSI min hydraulic supply
- 4. MIL-H-5606 oil
- 5. Test Set 7601

7-2 MAST CHARGING PRIOR TO EXTENSION

- A. PREPARATION (numbers and letters refer to name plate schematic)
 - 1. Connect test set 7601 in accordance with section 5-1A & B.
- B. CHARGING THE HYDRAULIC SYSTEM
 - 1. Close the manual hydraulic return valve.
 - 2. Open hydraulic supply valve (C). (Test Set)
 - 3. Start pump and set at 2000 PSI output.
 - a. Hydraulic accumulator level OK light will illuminate. (Test Set)
 - 4. Close hydraulic supply valve (C) as soon as level OK light comes on. (Test Set)
 - 5. Stop pump as soon as level OK light comes on.
- C. CHARGING THE PNEUMATIC SYSTEM
 - 1. Open the 200 PSI GN₂ supply.
 - Close the umbilical release simulate valve (AC). (Test Set)
 - a. The closed light should illuminate. (Test Set)
 - 3. Open pressure supply valve No. 2 (K).
 - 4. Adjust regulator #1 to 2000 PSI
 - 5. Adjust regulator #2 to 750 PSI
 - a. Open light will illuminate. (Test Set)

- b. Hydraulic return valve No. 1 (U) will close. (Test Set)
- c. Pressure supply valve No. 1 (J) will open. (Test Set)
- d. Gravity drain shutoff valve (W) will open. (Test Set)
 - (1) Mast may tend to rotate.
- e. Pneumatic accumulator PSI OK light will illuminate. (Test Set)
 - (1) Pressure supply valve Nos. 1 (J) and 2 (K) will close. (Test Set)
- 6. Return pressure supply valve No. 2 (K) switch to the DOWN position. (Test Set)
- 7. Place lock release switch (AJ) in the UP position. (Test Set)
 - a. The unlocked light on ball-locks Nos. 1, 2, 3, and 4, should illuminate. (Test Set)

D. MAST EXTENSION

1. The mast is now ready to extend. Refer to section 7-3, or in the event the hood control system has not been bled, refer to section 5-2.

7-3 MAST ARM EXTENSION

A. PREPARATION

- 1. Connect test set 7601 in accordance with section 5-1A & B.
- 2. Charge system in accordance with section 7-2.

B. MAST EXTENSION

- 1. CLOSE manual hydraulic return valve.
- 2. Place mast extend switch in UP position. (Test Set)
 - a. Four-way control valve (X) opens. (Test Set)
 - b. Cylinder supply valve (Y) closes. (Test Set)
- 3. Slowly OPEN manual hydraulic return valve.
 - a. MAST WILL EXTEND
- 4. Place mast extend switch in DOWN position after mast has extended.
 - a. Four-way control valve (X) returns to fire position. (Test Set)

b. Cylinder supply valve (Y) opens. (Test Set)

- 5. Close lock release valve (AJ). (Test Set)
 - a. Lock release closed light will illuminate. (Test Set)
 - b. Lock release open light will go off. (Test Set)
- 6. Control system may be de-energized and test panel secured for section 7-6, TEST SET SECURING AND CONTROL SYSTEM DE-ENERGIZING, or if retraction is required, proceed to section 7-4.

7-4 MAST CHARGING PRIOR TO RETRACTION

- A. CHARGING THE HYDRAULIC SYSTEM
 - 1. Turn on 28 VDC power supply and place test set power switch in ON position.
 - Close manual hydraulic return valve.
 - 3. Open hydraulic supply valve (C). (Test Set)
 - 4. Start pump and set at 2000 PSI output.
 - a. Hydraulic accumulator LEVEL OK light will illuminate. (Test Set)
 - 5. Close hydraulic supply valve (C) as soon as LEVEL OK light comes on. (Test Set)
 - 6. Stop pump as soon as LEVEL OK light comes on.
- B. CHARGING THE PNEUMATIC SYSTEM
 - 1. OPEN 2000 PSI GN₂ supply.
 - 2. CLOSE umbilical release simulate valve (AC). (Test Set)
 - a. Closed light should illuminate. (Test Set)
 - OPEN pressure supply valve No. 2 (K).
 - 4. Adjust regulator #1 to 2000 PSI
 - 5. Adjust regulator #2 to 750 PSI
 - a. Open light will illuminate. (Test Set)
 - b. Hydraulic return valve No. 1 (U) will close. (Test Set)
 - c. Pressure supply valve No. 1 (J) will open. (Test Set)
 - d. Gravity drain shutoff valve (W) will open. (Test Set)
 - e. Cylinder supply valve (Y) will open. (Test Set)
 - (1) Mast arm may tend to rotate.

- f. Pneumatic accumulator PSI OK light will illuminate (Test Set)
 - (1) Pressure supply valve Nos. 1 (J) and 2 (K) will close. (Test Set)
- 6. Return pressure supply valve No. 2 (K) switch to the DOWN position (Test Set)
- 7. Return the lock release valve (AJ) to the down position. (Test Set)
- 8. Remove the cable restraints from the front of the mast.

C. MAST RETRACTION

1. The mast is now ready to retract refer to section 7-5.

7-5 MAST ARM RETRACTION

A. PREPARATION

- 1. Connect test set 7601 in accordance with section 5-1A & B.
- 2. Charge system in accordance with section 7-4.

B. RETRACTION

- 1. Close manual hydraulic return valve.
- 2. Place lift-off simulator switch in UP position. (Test Set)
 - a. Umbilical release simulator valve (AC) opens. (Test Set)
 - b. Hydraulic return valves #1 (U) and #2 (V) opens. (Test Set)
- 3. Slowly OPEN manual hydraulic return valve
 - a. MAST WILL RETRACT
 - b. Lock indicator lights #1 through #4 will illuminate indicating locked position and unlock lights will go off. (Test Set)
 - c. Mast retracted and hood closed lights will illuminate. (Test Set)
- 4. Return lift-off simulator switch to DOWN position. (Test Set)
 - a. Umbilical release simulator valve (AC) closed light will illuminate. (Test Set)
- 5. Control system may now be de-energized and test panel secured per section 7-6, TEST SET SECURING AND CONTROL SYSTEM DE-ENERGIZING, or if extension is required, proceed to section 7-2, MAST CHARGING PRIOR TO EXTENSION.

7-6 TEST SET SECURING AND CONTROL SYSTEM DE-ENERGIZING

A. SECURING PROCEDURE

- 1. Connect safety cable assemblies between forward base lugs and arm lifting lugs (if mast is in the extended position).
- 2. Close 2000 PSI GN2 pneumatic supply.
- 3. Close manual hydraulic return valve.
- 4. Open pneumatic bleed valve (L). (Test Set)
- 5. When system is completely bled of air close pneumatic bleed valve (L). (Test Set)
- 6. Place all test set switches in down position. (Test Set)
- 7. All pneumatic and hydraulic supply and/or return lines may now be removed, and test set cables disconnected.

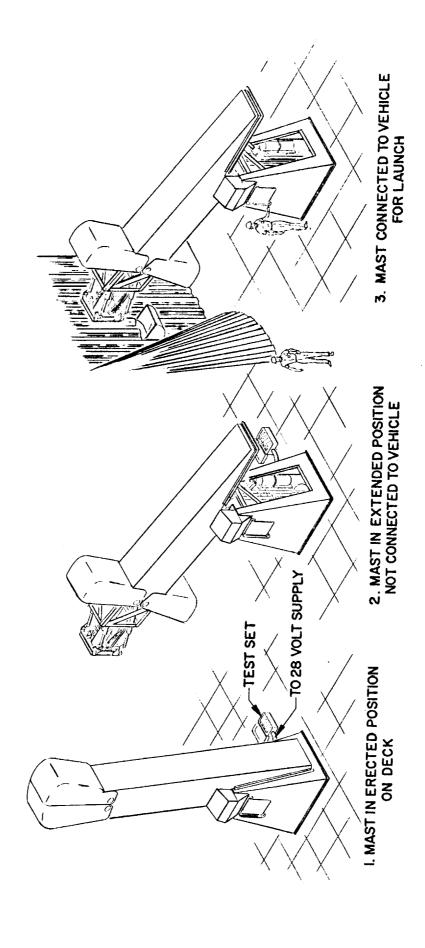


Fig. 7-1 The Tail Service Mast sequence

7-7 RELATED VEHICLE OPERATION

The Tail Service Mast is designed to start operation only after separation of the umbilical ground-half from the umbilical fly-half which is attached to the booster stage of the Saturn V vehicle. The umbilical ground-half will separate from the vehicle after either three inches rise of the vehicle for normal disconnect or after fifteen inches rise for what is referred to as "emergency" disconnect. Emergency disconnect will take place only if for some reason the umbilical ground-half does not separate from the vehicle fly-half during normal operation. The umbilical carrier is so designed that it will be mechanically removed from the vehicle fly-half by the vertical motion of the vehicle.

The pivot point of the Tail Service Mast arm is located 172 inches from the skin of the vehicle and is consequently in an area of high pressure and temperature during lift-off. The mast is rotated back away from the vehicle while the vehicle is in motion. The timing of the actual operating sequence is such that the mast will be retracted and the hood closed prior to temperature and pressure extremes.

The following diagrams illustrate the relative position of the Tail Service Mast and the Saturn V vehicle throughout the period of most severe environment. Since there does exist a difference in the operation times from "normal" and "emergency" disconnect both are illustrated.

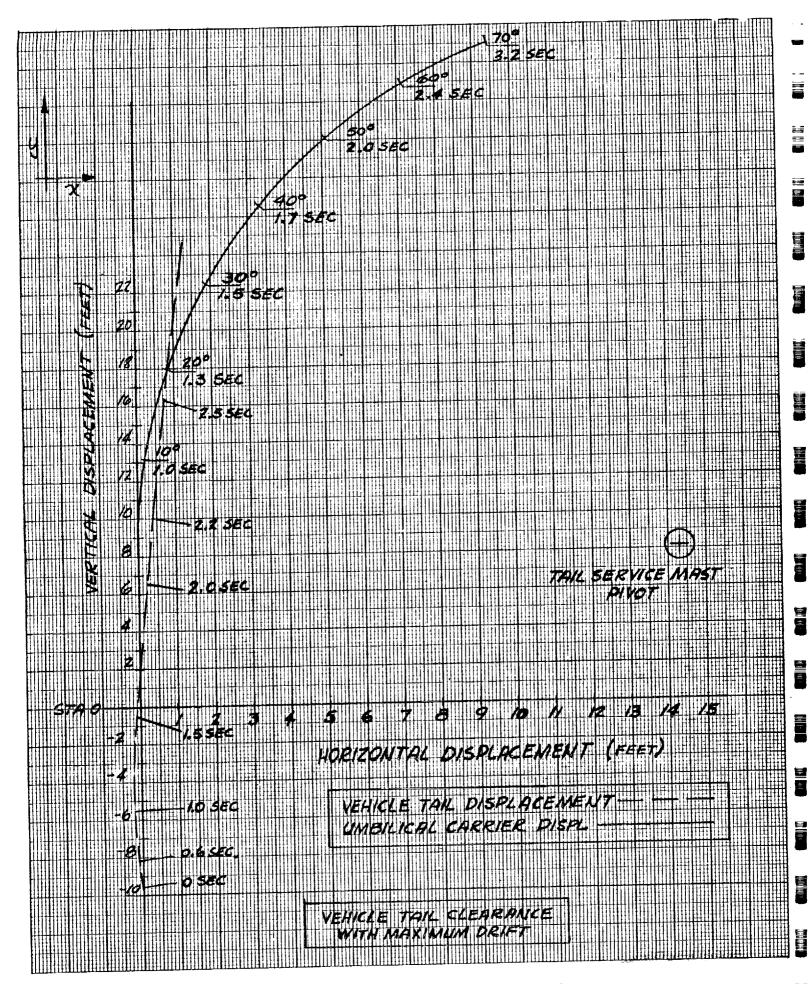


Fig. 7-2 Tail Service Mast and Vehicle Tail Clearance

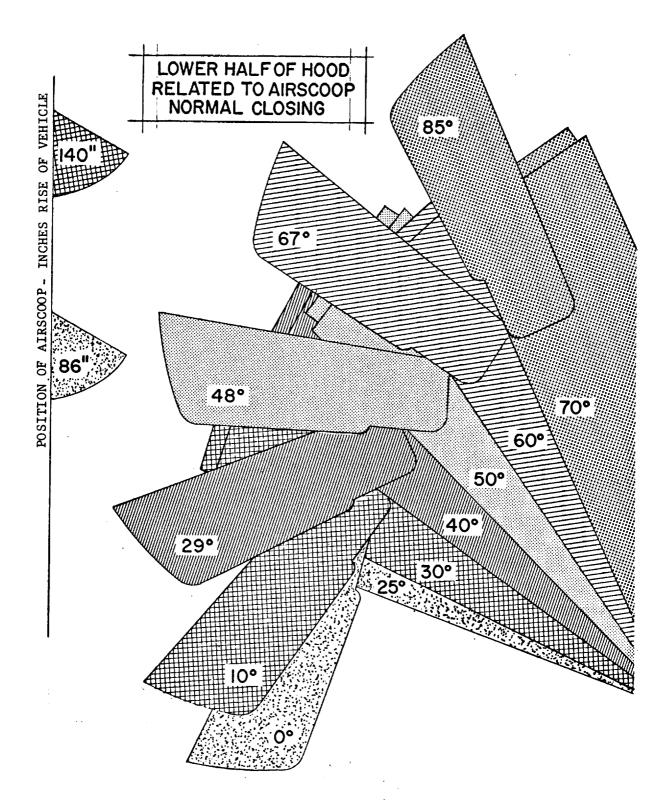
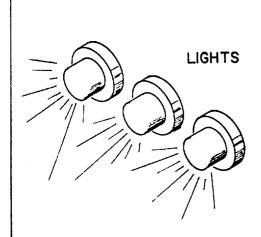


Fig. 7-3 Hood closing sequence at normal rate of closing



T-51 MIN

I. CHECK INDICATOR LIGHTS TO MAKE SURE THE HYD BYP V, 4 WAY V, AND HYD RET V#2 CLOSED LIGHTS ARE ON.



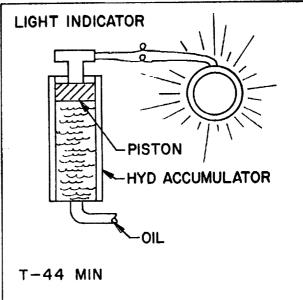
T-49.5 MIN

2. ACTUATE PNEU BLEED V SWITCH.



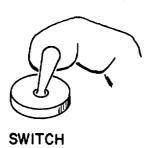
T-49 MIN

3. ACTUATE HYD SUP V SWITCH.



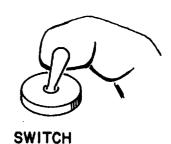
4. LIGHT INDICATES FULL ACCUMULATOR.

Fig. 7-4 The Tail Service Mast preparation sequence



T-45.5 MIN

5. PLACE HYD SUP V SWITCH IN DOWN POSITION.



T-43 MIN

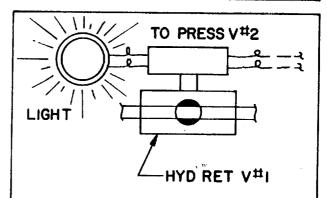
6. PLACE PNEU BLEED V SWITCH IN DOWN POSITION.



SWITCH

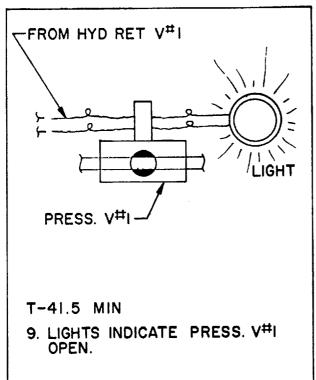
T-42 MIN

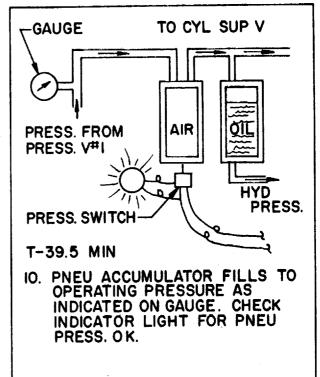
7. ACTIVATE PRESS. V#2 SWITCH

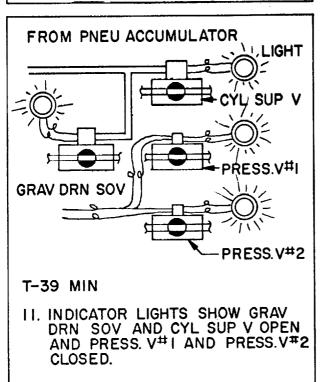


T-41.8 MIN

8. LIGHTS INDICATE PRESS. V#2 OPENS. HYD RET V IS CLOSED.







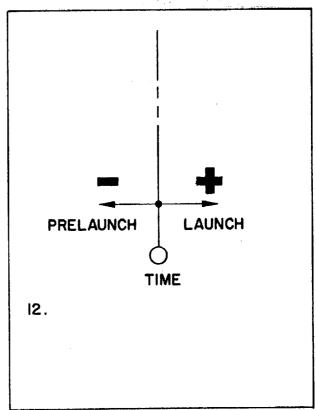
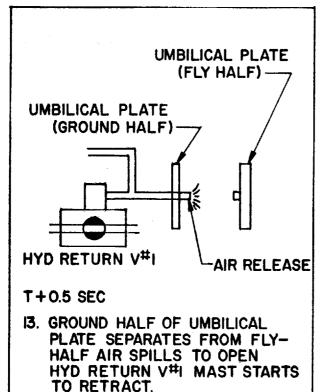
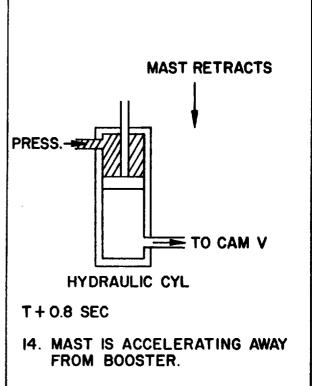
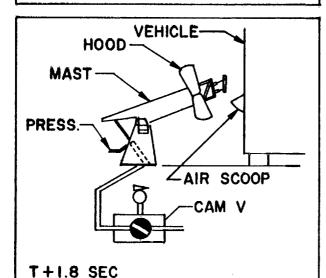


Fig. 7-6 The Tail Service Mast preparation sequence

7-12







15. MAST CLEARS AIR SCOOP OF

CLOSE.

BOOSTER. CAM V BEGINS TO

CLOSE TO DECELERATE MAST

MOVEMENT. HOOD STARTS TO

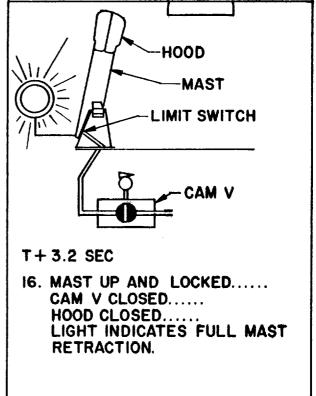


Fig. 7-7 The Tail Service Mast preparation sequence

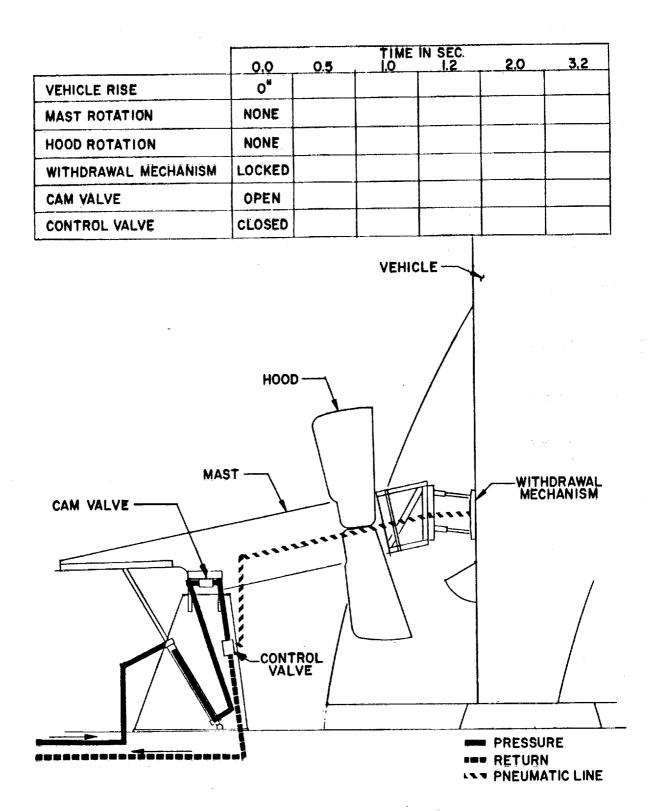


Fig. 7-8 Tail Service Mast operating sequence from normal disconnect

| | | | TIME | IN SEC. | | |
|----------------------|----------|-----------|-----------|---|----------|-------------------|
| | 0.0 | 0.5 | 1.0 | 1.2 | 2.0 | 3,2 |
| VEHICLE RISE | | 3" | | | | |
| MAST ROTATION | | NONE | | | | |
| HOOD ROTATION | | NONE | | | | |
| WITHDRAWAL MECHANISM | | UNLOCKED | | | | |
| CAM VALVE | | OPEN | | | | |
| CONTROL VALVE | | OPEN | | | | |
| | | | VEHICL | F-4/ | | |
| | | | | -//- | ~ | |
| | HOOD | | | // | | |
| | | | \neg /: | / | | |
| | | | | | 2.5" | |
| M | ast — | , \ | | | | |
| CAM VALVE | | | AFT | 11-11-11-11-11-11-11-11-11-11-11-11-11- | WITH MEC | HDRAWAL Hanism |
| | | | | | | |
| | 4444 | ***** | \A | | | |
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| | VA | ITROL / C | | | | / |
| | | 3" / | | | | |
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| | <u> </u> | 1 | | / | PRESSU | \ |
| | -1 | | | | RETURN | |
| | | | | ~~ | PNEUMA | TIC |

Fig. 7-9 Tail Service Mast operating sequence from normal disconnect

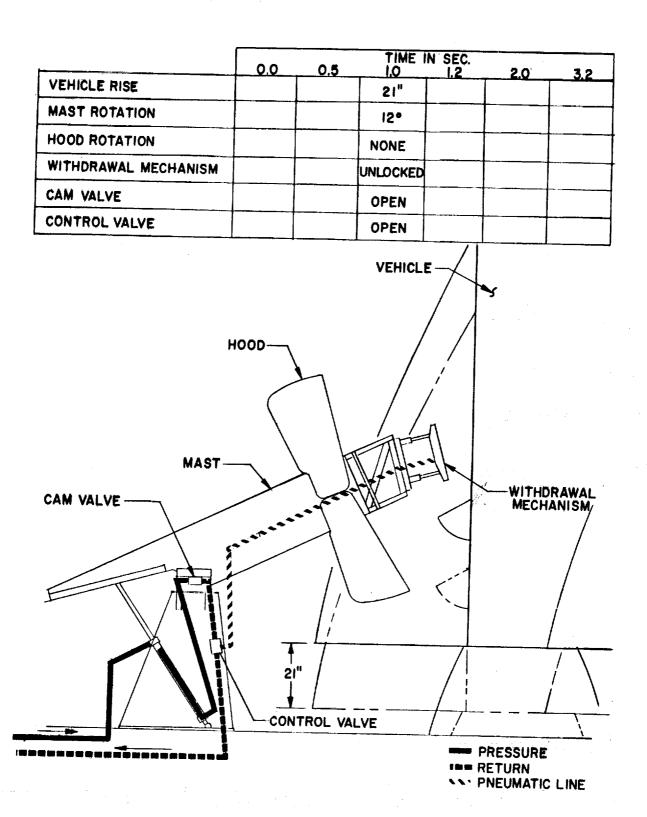


Fig. 7-10 Tail Service Mast operating sequence from normal disconnect

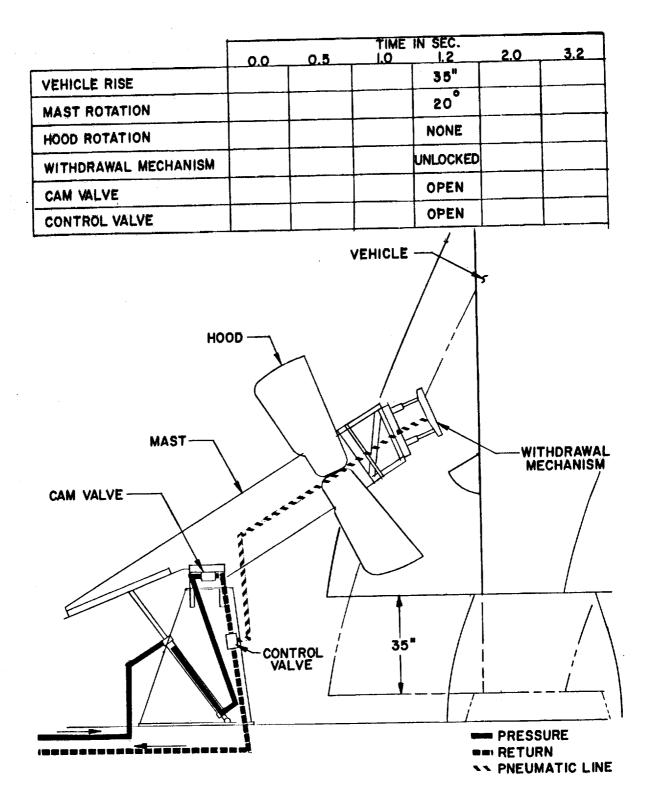


Fig. 7-11 Tail Service Mast operating sequence from normal disconnect

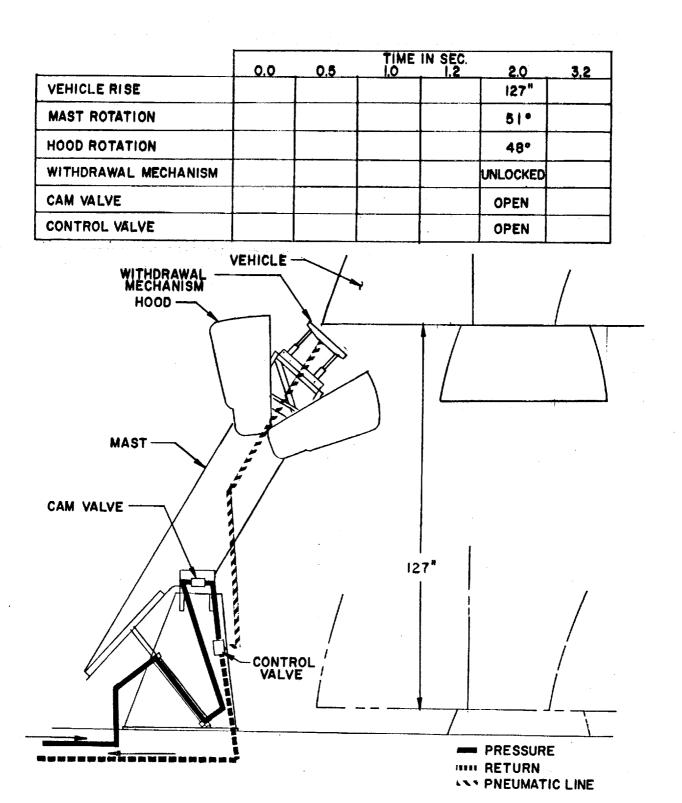


Fig. 7-12 Tail Service Mast operating sequence from normal disconnect

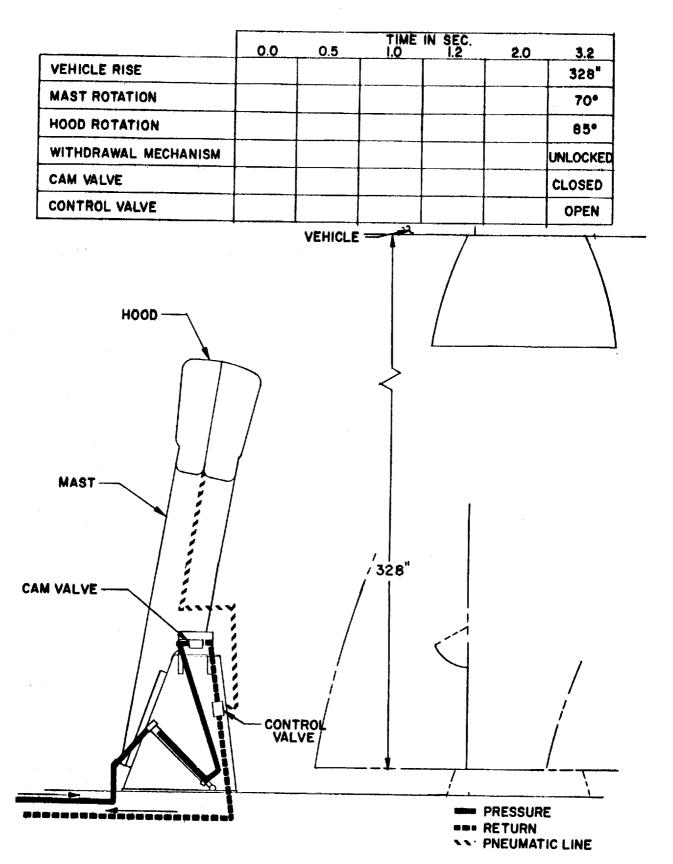


Fig. 7-13 Tail Service Mast operating sequence from normal disconnect

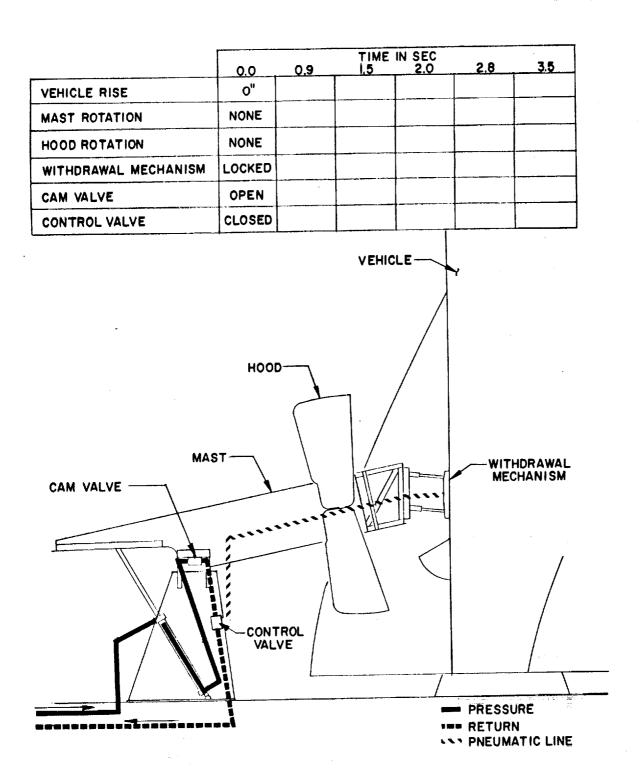


Fig. 7-14 Tail Service Mast operating sequence from emergency disconnect

| | 0.0 | 0.9 | TIME | N SEC. 20 | 2.8 | 3.5 |
|----------------------|-----|----------|------|--------------|-----|-----|
| VEHICLE RISE | | 15" | | | | |
| MAST ROTATION | | NONE | | | | |
| HOOD ROTATION | | NONE | | | | |
| WITHDRAWAL MECHANISM | | UNLOCKED | | | | |
| CAM VALVE | | OPEN | | | | |
| CONTROL VALVE | | OPEN | | | | |

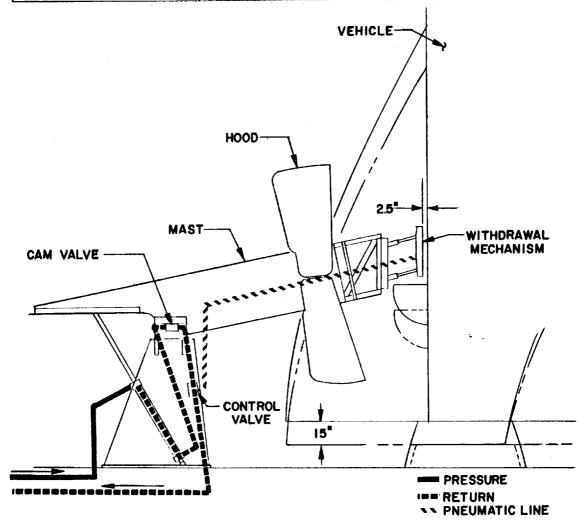


Fig. 7-15 Tail Service Mast operating sequence from emergency disconnect

| | | · · · · · · · · · · · · · · · · · · · | TIME | IN SEC. | | |
|-----------------------|-----|---------------------------------------|----------|---------|-----|------|
| | 0.0 | 0.9 | 1.5 | 2,0 | 2.8 | 3.5 |
| VEHICLE RISE | · | • | 6A" | | | |
| MAST ROTATION | | | 15* | | | |
| HOOD ROTATION | • | | NONE | | | ···· |
| WITHDRAWAL MECHANISM. | | | UNLOCKED | | | |
| CAM VALVE | | W. P | OPEN | | | |
| CONTROL VALVE | | | OPEN | | | |

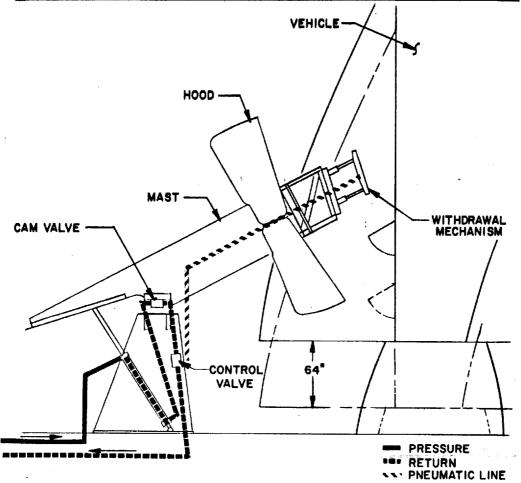


Fig. 7-16 Tail Service Mast operating sequence from emergency disconnect

| | 0.0 | 0.9 | TIME 1.5 | IN SÉC. 2.0 | 2,8 | 3.5 |
|----------------------|-----|-----|-------------|----------------|-----|-----|
| VEHICLE RISE | | | | 127" | | |
| MAST ROTATION | | | | 36° | | |
| HOOD ROTATION | . , | | | 21* | | , |
| WITHDRAWAL MECHANISM | | | | UNLOCKED | | |
| CAM VALVE | | | | OPEN | | |
| CONTROL VALVE | | | | OPEN | | |

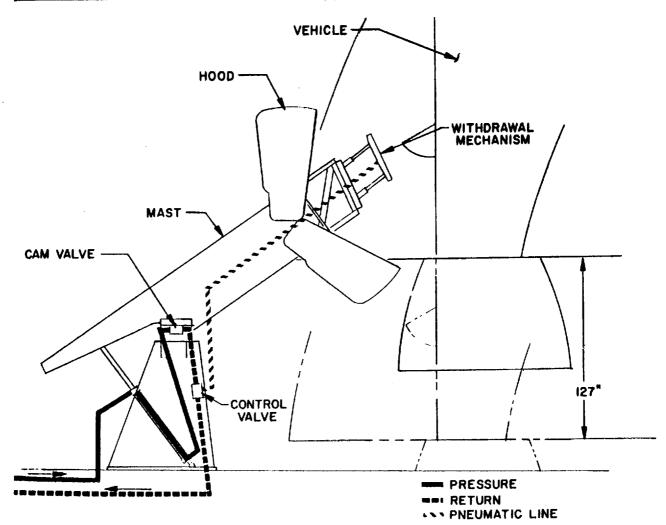


Fig. 7-17 Tail Service Mast operating sequence from emergency disconnect

| | ~~~ | 0.0 | TIME | IN SEC. | 2.0 | 3.5 |
|----------------------|-----------------|--------|----------------|----------|--------------|-----|
| VEHICLE RISE | 0.0 | 0.9 | 1.5 | 2.0 | 2.8 278" | 3.5 |
| | | | | | | |
| MAST ROTATION | | | | | 62° | |
| HOOD ROTATION | | | | | 70° | · |
| WITHDRAWAL MECHANISM | | | • | | UNLOCKED | |
| CAM VALVE | | | | | OPEN | |
| CONTROL VALVE | | | | | OPEN | |
| WITHDRAWAL | EHICLE | + | | , | | |
| HOOD | | | | | | |
| CAM VALVE | | , / | 78" / | | | |
| | - CONTR VALV | OL E | | | | / |
| | 1 | | | , | | |

Fig. 7-18 Tail Service Mast operating sequence from emergency disconnect

=== RETURN

--- PNENMATIC LINE

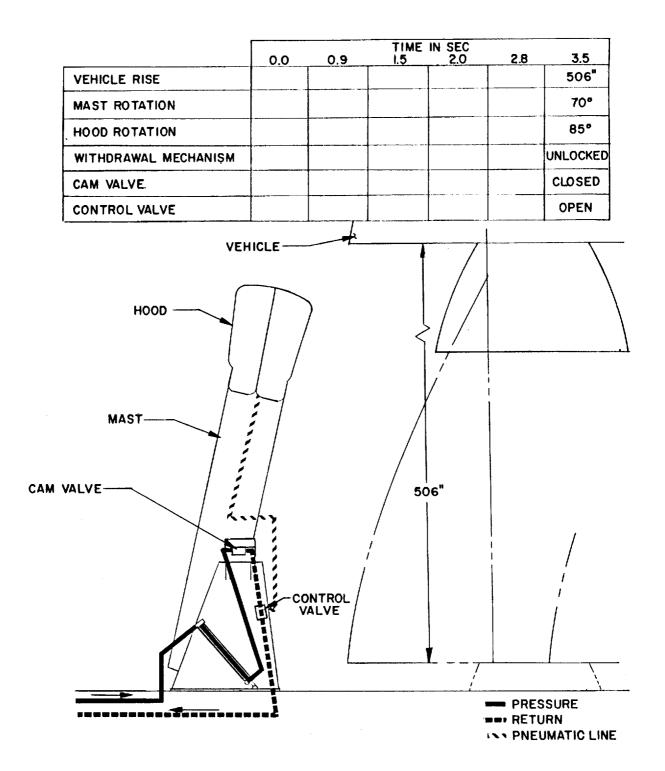


Fig. 7-19 Tail Service Mast operating sequence from emergency disconnect

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SECTION VIII DESIGN ANALYSIS

8-I MOTION ANALYSIS

8-2 VIBRATION ANALYSIS

8-3 STRESS ANALYSIS

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- A angle as noted (deg)
- A area (in²)
- C arbitrary distance as noted (in)
- F force on cylinders (lbs)
- I mass moment of inertia (ft-lb-sec2)
- i initial values
- $K 10^3$
- L length of cylinders including shaft (in,ft)
- $M mass (1b sec^2/ft)$
- P pressure (lb/in²)
- P1 pivot point of mast on base
- P₂ pivot point of cylinder on mast
- P₃ pivot point of cylinder on base
- P4 pivot point of umbilical retracting arms on mast
- Q flow (in³/sec, gal/min)
- R arbitrary distance as noted (in)
- S displacement or stroke of piston (in)
- T torque about pivot P₁ (ft-lb)
- Th torque imposed upon system by hood (ft-lb)
- T_t total torque required about pivot P_1 (ft-1b)
- t time (sec,min)
- V volume (in³, ft³, gal)
- v velocity (in/sec, ft/sec)

MOTION ANALYSIS LEGEND (Continued)

- W weight (lbs)
- Y vertical displacement (in,ft)
- Ya vertical position of umbilical attachment (in)
- Ys vertical position of airscoop (in)
- Ø angle of rotation of mast (deg)
- angular velocity of mast (rad/sec)
- angular acceleration of mast (rad/sec²)
- angle as noted (deg)
- (3 angle as noted (deg)
- 9 angle as noted (deg)
- r distance to center of gravity (in,ft)
- // dynamic viscosity (1b-sec/ft2)
- S small change in angle
- A small change in quantity
- \approx approximately equal to
- ρ density (1b, \sec^2/in^4)

TM-23-0-D SECTION VIII DESIGN ANALYSIS

8-1 MOTION ANALYSIS

This report presents information relating the motion of the Tail

Service Mast to that of the Saturn V vehicle. Design criteria has been presented as an aid in determining the overall operating parameters of the Tail Service Mast.

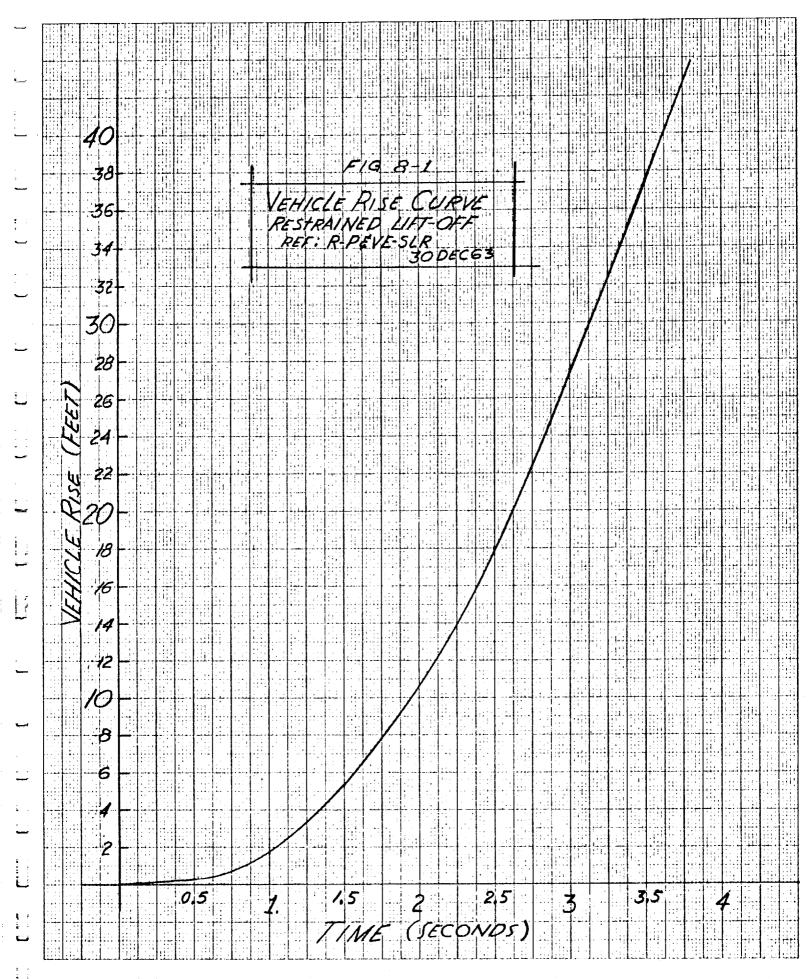
The successful operation of the Tail Service Mast depends upon:

1) the time available to clear the flight path of the vehicle and remove the mast to an area of lower temperatures and less direct exhaust impingement 2) designing into the fabricated members an optimum strength to weight ratio 3) a feasible hydraulic system and 4) a triggering system with the least reaction time and greatest degree of probability. Calculations show that each of the above can be met with a reasonable margin of safety.

All calculations are based upon the best information available and are not to be taken as final. The information presented here is intended at best to be a guide for the final design of the Tail Service Mast. For instance in the section on determining the pressure differential across the piston no additional pressure has been added for friction or line pressure drops and it is recommended that these figures be multiplied by a factor of at least 1.5 for the pressure at the accumulator. Curves have been provided to show the relation of the tail of the vehicle to the Mast as a means of estimating the temperature and pressure ranges that the mast will be subjected to throughout its entire motion. Curves on the pressure and flow on both the input side and the output side of the cylinders and

data on the pressure drop across the cam valve have been provided as an aid in the design of the control cam. All information has been tabulated as a reference for correlating parameters.

- 1. The design criteria used to establish the operating parameters of the Tail Service Mast are presented here as a reference. Changes in design criteria may of necessity change operating parameters of the Mast.
- a. Pivot point of the Tail Service Mast at 172 inches from skin of vehicle and at station 98.45.
- b. Air Scoop located on vehicle at station 112 and extending 20 inches from skin of vehicle at -30° .
- c. Umbilical attachment disengages from vehicle at three (3) inches above nominal position for "normal" disconnect or fifteen (15) inches above nominal position for "emergency" disconnect.
- d. Tail Service Mast may be allowed to travel until vehicle reaches a height of ten (10) feet above the mast in the up and locked position.
- e. Time will be taken as equal to zero when holddown arms are released from vehicle.
- f. Tail Service Mast motor section will be two 3 1/4" bore hydraulic cylinders with two inch connecting shafts on the input side.
- g. Motion for the vehicle will be restrained for first 10 inches vertical travel.



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|---------------------------------------|------|---|------|------|-----|-----|------|----|----|----|----|------|---|-----------|----|----|-----------|----------|----|--|----|--------|----|------------|-----------------------|-----------|-------|------------|----|-------|--------------|---------|--------------------|----|------|---|--|
| | | | | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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A. KINEMATICS The main objective of this motion analysis is to determine that there will be clearance between the vehicle flight envelope and the umbilical carrier during the initial lift-off phase of the vehicle. After separation of the ground-half umbilical plate from the vehicle the Service Mast is to be moved to an area of lower temperature and less direct engine exhaust impingement in a minimum of time.

A critical area of clearance within the flight envelope is an air scoop located on the vehicle directly below the umbilical attachment and extending twenty (20) inches from the skin of the vehicle. The hood which will cover the umbilical carrier during liftoff will not begin closing until the mast has rotated through approximately 25 degrees. This will prevent interference of the hood with the airscoop.

The Tail Service Mast will rotate through a total of 70 degrees in less than 3 seconds. The first few degrees of rotation, however, will determine the acceleration rate of the mast.

A time reference position for calculation purposes will be set up to coincide with the time frame of the vehicle. Time will be taken as equal to zero when the hold-down clamps are released from the vehicle.

Figures 8-1 & 8-2 are time-space curves of the vehicle and can be used to determine the time available for clearance of the flight path of the airscoop.

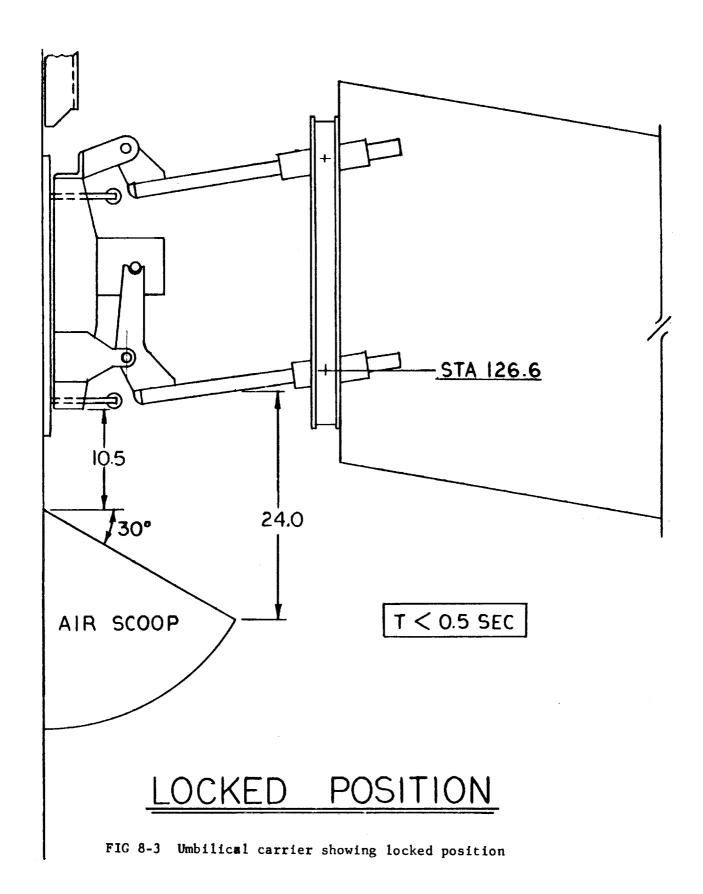
The umbilical carrier is so designed that there are two maximum positions that it may disconnect from the vehicle fly-half. The first position is referred to as "normal" disconnect and occurs at three (3) inches rise of the vehicle above nominal position. The second position

is referred to as "emergency" disconnect and will occur at fifteen (15) inches rise of the vehicle above nominal position.

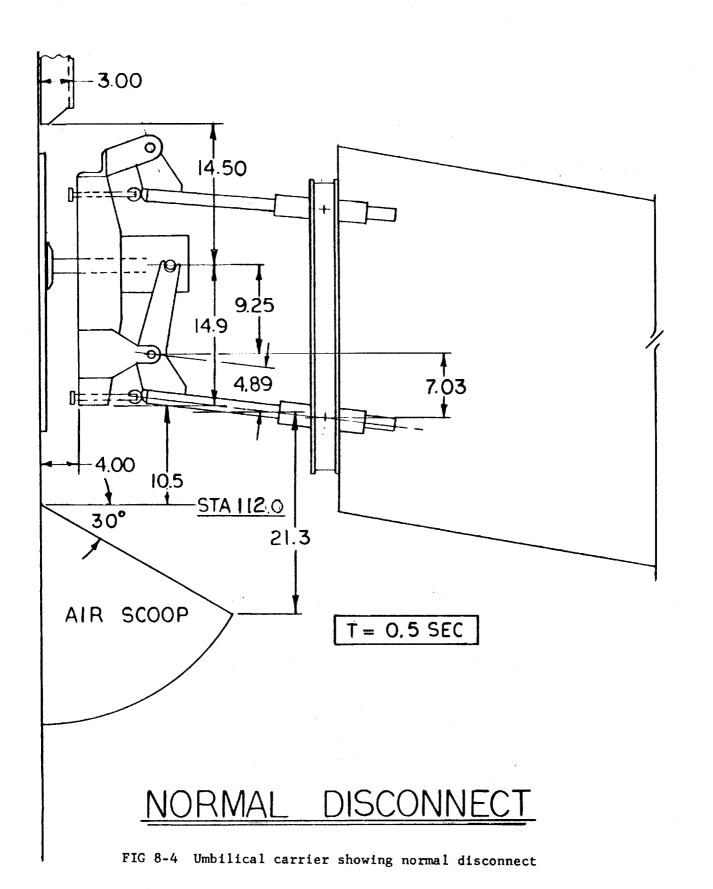
The Saturn V vehicle is to use restrained motion for the first ten (10) inches vertical rise. From figure 8-2 normal disconnect occurs at t = 0.5 seconds and emergency disconnect occurs at t = 0.9 seconds. From the plume configuration of the Saturn V engines it was established that the mast may be allowed to travel until the engines are approximately ten (10) feet above the mast with the mast in the up and locked position. The bottom of the engines reach this position at t = 3.5 seconds. This gives a total time of travel available for the mast of 3.0 seconds from normal disconnect and a total available time of travel of 2.6 seconds from emergency disconnect.

The umbilical attachment is moving with the vehicle, however, the mast has not begun to rotate until the attachment has completely disconnected. Figures 8-3, 4, & 5 show the position of the umbilical carrier with respect to the airscoop for the three positions of unlocked, normal, and emergency disconnect. From these it can be seen that the retracting arms come closer to the airscoop during emergency disconnect. Since the distance from the pivot point of the mast to a point on the umbilical ground-half is different for the two positions it will be necessary to check the actual time-space parameters for the mast.

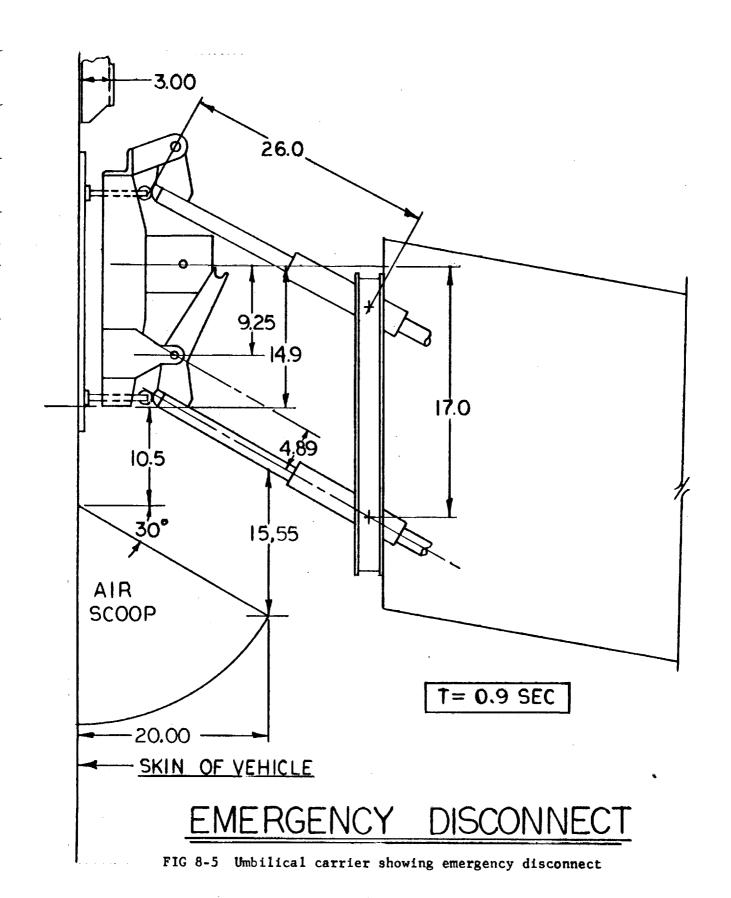
A geometry drawing connecting the reference points of the mast is shown in figure 8-6. For normal disconnect Y is the initial position of Point A at disconnect and is the difference between station 125.5 and 98.45 which is the station of the pivot point P1. The bottom of the



8-9



8-10



8-11

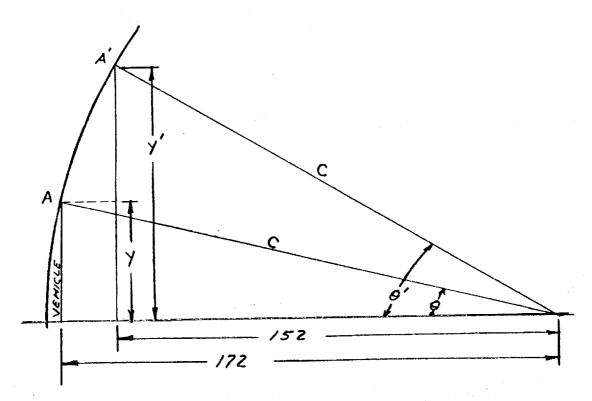


FIG 8-6 Determining angle of rotation of Mast

umbilical plate is 10.5 inches above the airscoop which is at station 112. The addition of the three inches rise for disconnect puts point \underline{A} at station 125.5 for a difference of 27.5 inches.

$$C = \sqrt{(172)^2 + (27.5)^2} = 174 \text{ in.}$$

$$\theta = \text{Arctan } (27.5/172) = 9.1^{\circ}$$

$$\theta' = \text{Arcos } (152/174) = 29.1^{\circ}$$

$$\emptyset = \theta' - \theta. = 20^{\circ}$$

The vertical distance the umbilical attachment travels will be Y' - Y. 152 sin 29.1° - 27.5 = 46.4 in.

This will also be the vertical rise of the vehicle to maintain the initial distance between the airscoop and the umbilical ground-half. From figure 8-2 the vehicle travels this distance in approximately 0.87 seconds from normal disconnect position. An acceleration of less than 1 rad/sec² would be sufficient to move the mast out of the flight path with this much time.

For emergency disconnect and using fifteen (15) inches rise point \underline{A} will be at station 137.5 for a difference of 39 inches.

$$C = \sqrt{(172)^2 + (39)^2} = 176.4 \text{ in.}$$

$$\theta = Arctan (39/172) = 12.8^{\circ}$$

$$\theta$$
 = Arccos (152/176.4) = 30.5

$$\emptyset = 17.7^{\circ}$$

The vertical distance the umbilical attachment travels is $176.4\sin 30.5 - 39 = 50.5in$

To maintain the initial distance between the attachment and the airscoop from figure 8-2 the vehicle rises this distance in 0.62 seconds from emergency disconnect position.

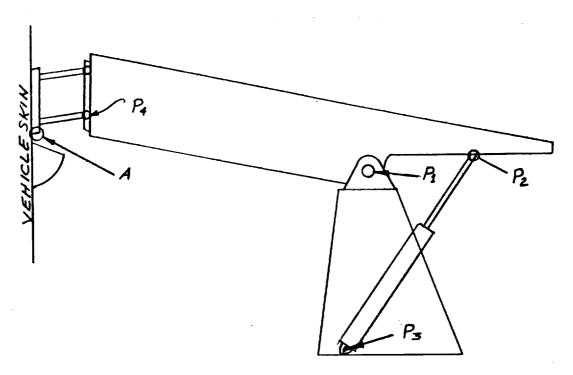


FIG 8-7 Tail service mast showing reference points

These are the times allowed for the umbilical carrier to just clear the airscoop and does not allow for any additional clearance which must be taken into consideration for safety.

For emergency disconnect to determine the acceleration rate the 17.7° is used.

$$\propto = \frac{2 \not 0}{t^2} = \frac{2(0.3)}{0.384} = 1.56 \text{ rad/sec}^2$$

This is the minimum constant acceleration required to move the mast from the flight path of the airscoop in 0.62 seconds. The motor section of the mast will not be capable of maintaining a constant acceleration rate, however, and a higher initial acceleration must be specified. In order to keep the acceleration as low as possible and to allow for maximum time the distance between the umbilical carrier and the airscoop was allowed to decrease slightly until the mast could gain momentum. This gave the necessary time to get the mast started after disconnect and exceed the velocity of the rising vehicle.

The following tables and graphs show the motion of the Tail Service Mast relative to the time frame of the vehicle. Calculations will be made using the time-space parameters for emergency disconnect. Information concerning normal disconnect is included for reference.

To determine the angle of rotation of the mast consider the carrier as having moved to emergency position and connect the pivot points of the mast and lower retracting arms of the umbilical carrier with an arbitrary line R. As the mast rotates about the pivot P₁ the near point Ya moves along the retracting arm away from point P₄.

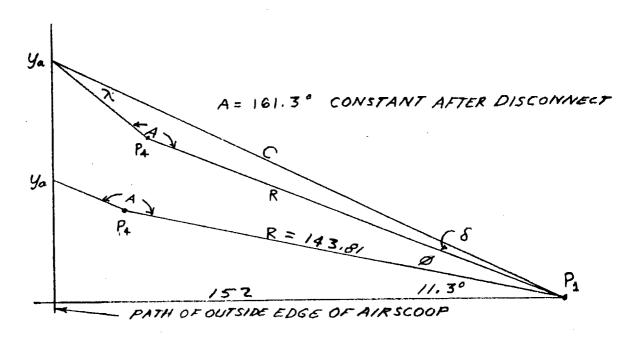


FIG 8-8 Geometry for determining angle of rotation of mast

To determine the angle Ø from figure 8-8.

$$C = \sqrt{(152)^2 + Y^2}$$

$$\lambda = Arcsin \left[(R/C)(sin A) \right]$$

$$\delta = 180 - (\lambda + A)$$

$$\theta = Arctan (y/152) - (\delta + 11.3^\circ)$$
(8-1)

y at all times will have to be taken as a point on the centerline of the retracting arms. On figure 8-11 corrections have been made to consider

the radius of the retracting arms and the lower projecting ground-half of the umbilical attachment.

Example for determing Ø

Since the position of the airscoop is known the distance of the attachment may be set for any desired separation. An arbitrary datum is selected through the pivot point of the mast at station 98.45 (P1) and Y is measured from that.

For a separation of Ya - Ys ≈ 11 in

$$Y = 57$$
 at $f = 1.2$ sec

$$C = \sqrt{(152)^2 + (57)^2} = 162.3$$

 $\lambda = Arcsin (143.8/162.3)(sin 161.3) = 16.5^{\circ}$

$$\delta = 180 - (16.5 + 161.2) = 2.2^{\circ}$$

$$\emptyset$$
 = Arctan (57/152) - (2.2 + 11.3) = 6.9°

This will be the angle the mast has rotated through in order to keep the umbilical carrier ahead of the airscoop. Only those values of \$\psi\$ through approximately 25° were convenient to calculate. Since the rotation of the mast was not expected to vary erratically it was desired to obtain the remaining values by drawing a smooth curve approaching a zero slope at the end of the stroke. From this curve the velocity and acceleration were plotted. Once the acceleration values are available it is possible to find the torque required about the pivot point P1.

NORMAL DISCONNECT

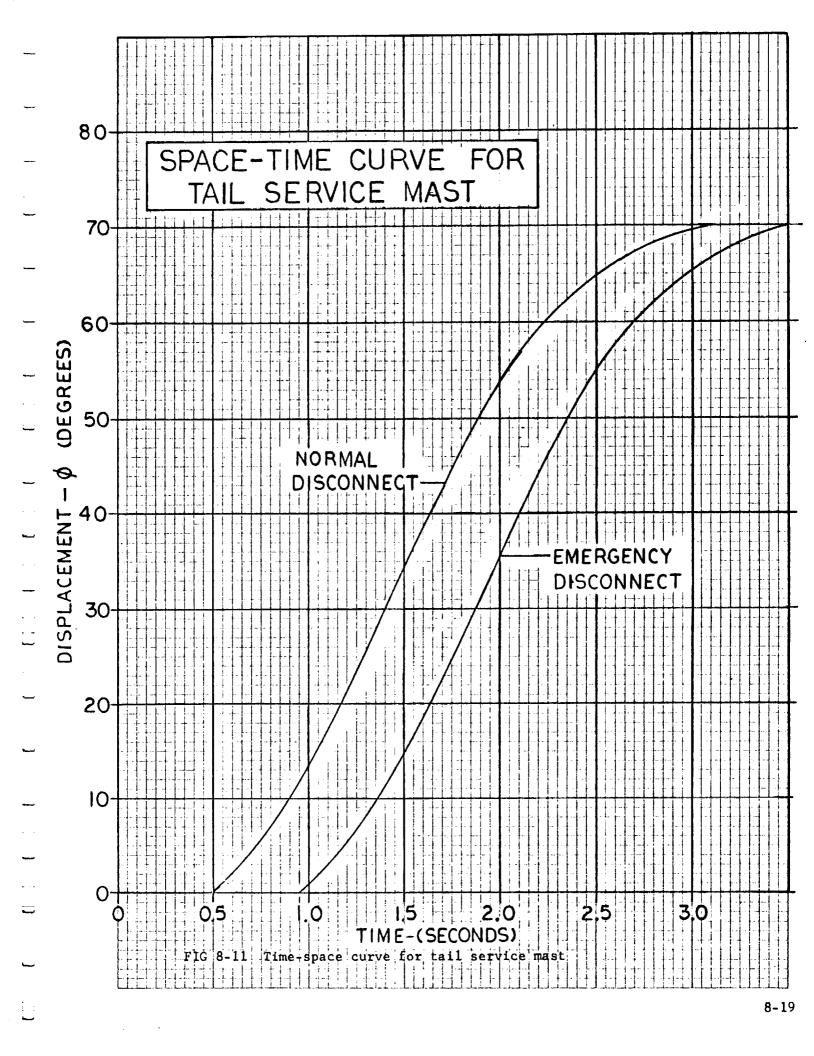
| TT TATE | VEHICLE SIME RISE | | 3.9 | • | | 4 |
|---------|----------------------|-------|------|------|-------|----------|
| TIME | К. | 12E | Ys | Ya | Ya-Ys | <u> </u> |
| SEC | FT | IN | IN | IN | /N | Deg |
| 0 | 0 | 0 | 13.5 | 24 | 10.5 | 0 |
| • 5 | 0.25 | 3 | 16.5 | 27 | 10.5 | Ö |
| •6 | 0.4 | 4.8 | 21.9 | 31.6 | 9.7 | 2.0 |
| • 7 | 0.6 | 7.2 | 27.4 | 37.8 | 10.4 | 4.2 |
| .8 | 0.8 | 9.6 | 33.7 | 45 | 11.3 | 7.0 |
| •9 | 1.25 | 15.0 | 40.5 | 52 | 11.5 | 10.0 |
| 1.0 | 1.8 | 21.6 | 47.3 | 62.1 | 14.8 | 13.2 |
| 1.1 | 2.4 | 28.8 | 56.3 | 70.3 | 14.0 | 17.0 |
| 1.2 | 3.0 | 36.0 | | | | 21.0 |
| 1.3 | 3.8 | 45.6 | | | | 25.5 |
| 1.4 | 4.4 | 52.8 | | | | 30.0 |
| 1.5 | 5.4 | 64.8 | | | | 34.0 |
| 1.6 | 6.4 | 76.8 | | | | 38.5 |
| 1.7 | 7.2 | 86.4 | | | | 42.6 |
| 1.8 | 8.4 | 100.8 | | | | 47.0 |
| 1.9 | 9.4 | 112.8 | | | | 50.0 |
| 2.0 | 10.6 | 127.2 | | | • | 53.7 |
| 2.1 | 11.8 | 141.6 | | | | 56.6 |
| 2.2 | 13.2 | 158.4 | | | | 59.2 |
| 2.3 | 14.6 | 175.2 | | | | 61.4 |
| 2.4 | 16.2 | 194.4 | | | | 63.2 |
| 2.5 | 18.0 | 216 | | | | 65.0 |
| 2.6 | 19.6 | 235.2 | | | | 66.0 |
| 2.7 | 21.4 | 256.8 | | | | 67.2 |
| 2.8 | 23.2 | 278.4 | | | | 68.0 |
| 2.9 | 25.2 | 302.4 | | | | 69.0 |
| 3.0 | 27.4 | 328.8 | | | | 69.5 |
| 3.2 | 31.4 | 376.8 | | | | 70 |

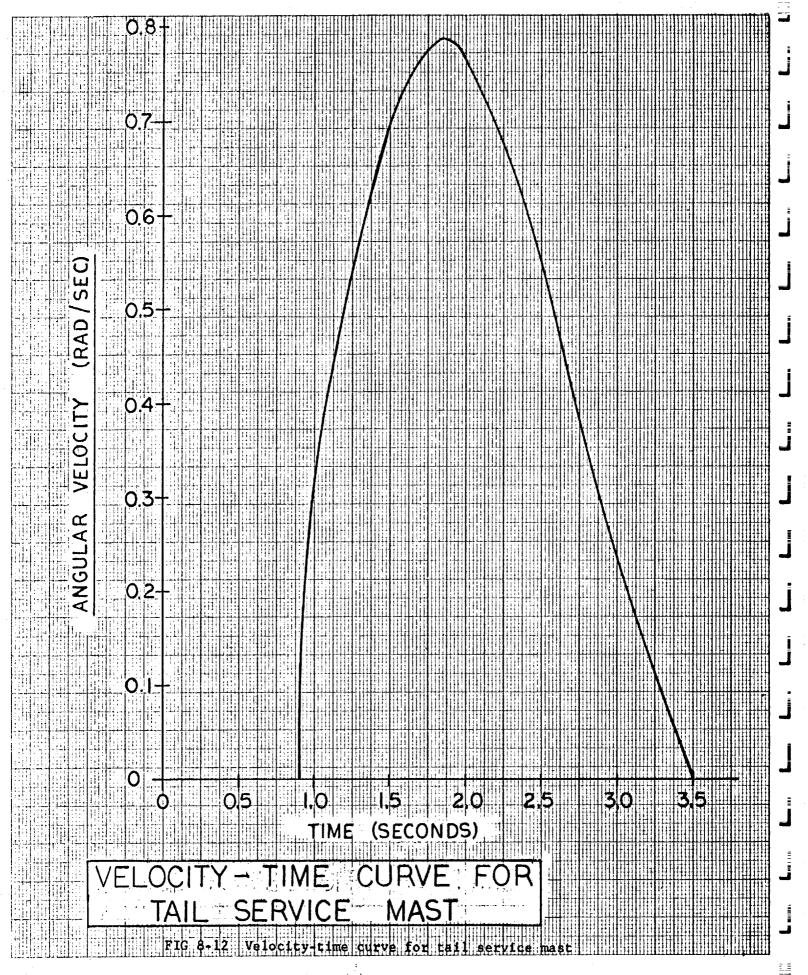
FIG. 8-9. OPERATING PARAMETERS FOR NORMAL DISCONNECT

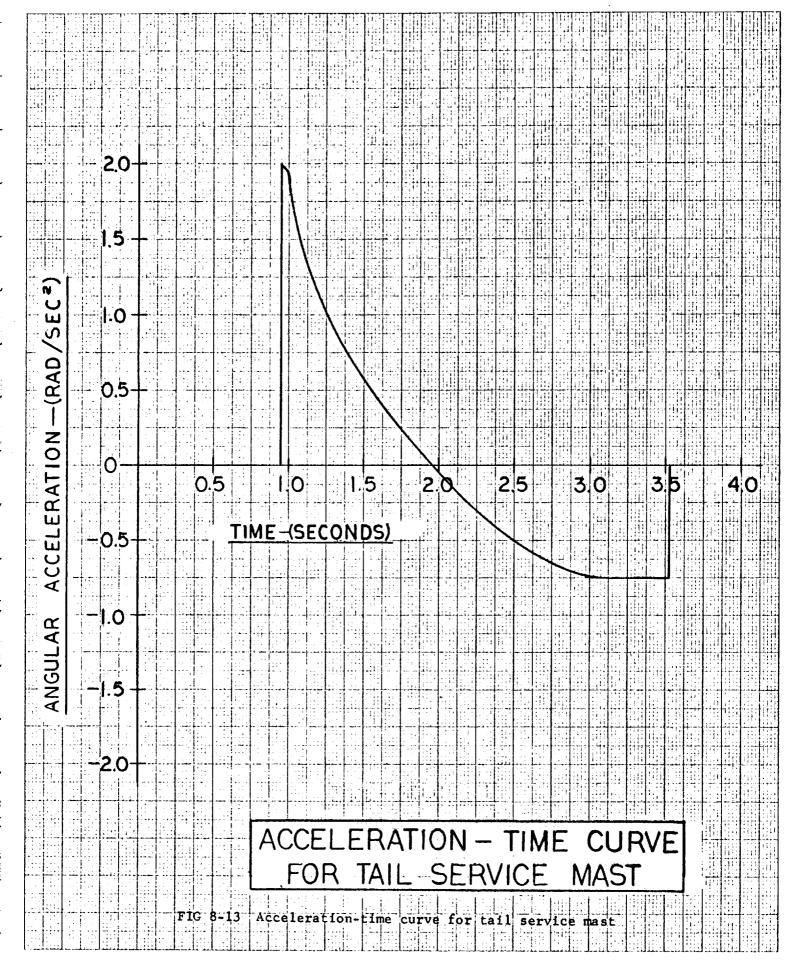
EMERGENCY DISCONNECT

| TIME | | ICLE ISE | Ys | Ya | Ya-Ys | ø | | |
|-------|-------|-------------|-----------|--------------|-------|------|---------|----------------------|
| (SEC) | FT. | IN. | IN | IN | IN | DEG | RAD/SEC | RAD/SEC ² |
| 0 | 0 | 0 | 13.5 | 24.0 | 10.5 | 0, | 0 | 0 |
| .9 | 1.25 | 15 | 28.5 | 39 | 10.5 | 0 | 0 | 2.0 |
| 1.0 | 1.75 | 21 | 33.88 | 43.6 | 9.7 | 1.5 | 0.32 | 1.80 |
| 1.1 | 2.25 | 27 | 39.4/ | 49.8 | 10.4 | 3.6 | 0.41 | 1.40 |
| 1.2 | 2.92 | 35 | 45.6 | 56.9 | 11.3 | 6.0 | 0.50 | 1.05 |
| 1.3 | 3.63 | 43.5 | 52.6 | 64.1 | 11.5 | 8.5 | 0.59 | 0.85 |
| 1.4 | 4.38 | 52.5 | 59.2 | 74 | 14.8 | 12.0 | 0.63 | 0.65 |
| 1.5 | 5.29 | 63.5 | 68.3 | 82.3 | 14.0 | 15.0 | 0.69 | 0.45 |
| 1.6 | 6.25 | 75 | | | | 19.0 | 0.73 | 0.30 |
| 1.7 | 7.29 | 87.5 | | | | 23 | 0.75 | 0.15 |
| 1.8 | 8.33 | 100 | • | | | 27.5 | 0.76 | 0.05 |
| 1.9 | 9.42 | 113 | | | | 31.5 | 0.76 | -0.05 |
| 2.0 | 10.60 | 127.2 | | | | 36 | 0.75 | -0.15 |
| 2.1 | 11.80 | 141.6 | | | | 40 | 0.73 | -0.25 |
| 2.2 | 13.0 | 156 | | | | 44 | 0.69 | -0.35 |
| 2.3 | 14.60 | 175.2 | | | | 48 | 0.65 | -0.45 |
| 2.4 | 16.20 | 194.4 | | | | 51 | 0.59 | -0.50 |
| 2.5 | 17.80 | 213.6 | | | | 54.5 | 0.52 | -0.55 |
| 2.6 | 19.80 | 237.6 | | | | 57.5 | 0.44 | -0.60 |
| 2.7 | 21.60 | 259.2 | | | | 60 | 0.38 | -0.65 |
| 2.8 | 23.20 | 278.4 | | | | 62 | 0.33 | -0.70 |
| 2.9 | 25.20 | 302.4 | | ₹ . | | 63.7 | 0.29 | -0.70 |
| 3.0 | 27.50 | 326.4 | 7 · 7 · 1 | 12. | | 65 | 0.24 | -0.75 |
| 3.5 | 37.50 | 450 | | e was in the | | 70 | 0 | -0.75 |

FIG. 8-10. OPERATING PARAMETERS FOR EMERGENCY DISCONNECT







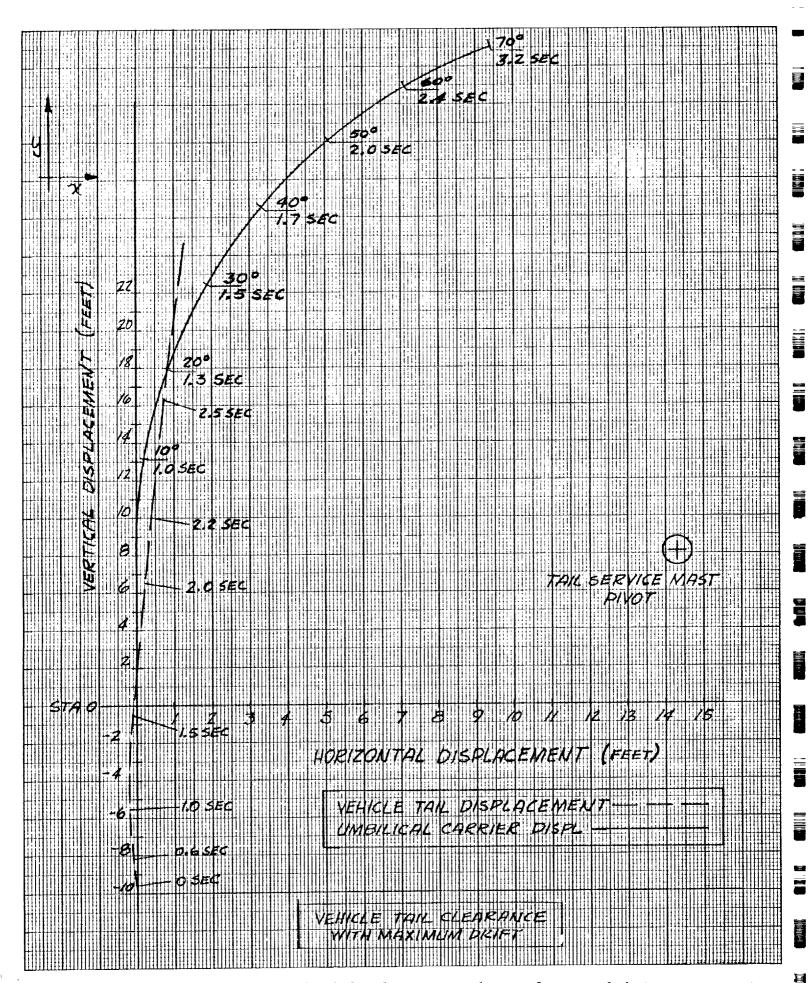


Fig 8-14 Vehicle tail and umbilical carrier relation for normal disconnect

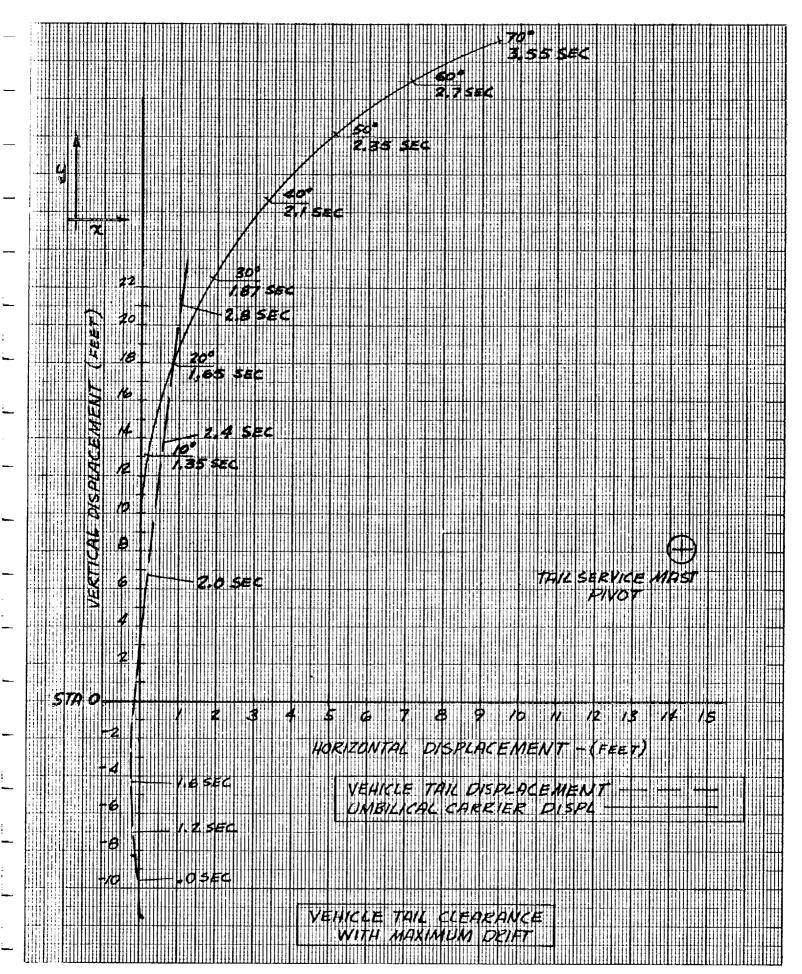


Fig 8-15 Vehicle tail and umbilical carrier relation for emergency disconnect

B. KINETICS. The force required of the hydraulic cylinders may be determined by considering the dynamic and static load on the mast. A load diagram is made of the mast and it is broken up into sections. By breaking the mast up into relatively small sections it can be assumed that the reversed effective forces will act through the center of gravity of the section thereby eliminating the need for finding a moment of inertia and center of percussion. Due to the relatively small angular velocity attained the $mr\omega^2$ term may be neglected leaving only the $mr\alpha$ term and the weight to cause moment about the pivot point of the mast.

Using the load diagram and summing moments about the pivot point leaves an unbalance of 45455.52 ft-1b which must be made up by the cylinders.

To utilize hydraulic cylinders as the driving unit instead of rotary actuators placement of the cylinders is a compromise between best mechanical advantage, stroke, and position to obtain maximum velocity within the early stages of movement.

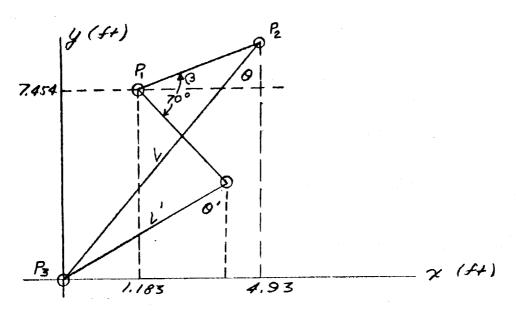


FIG 8-16

=

Figure 8-16 is a schematic of the motor section of the mast. P1 is the pivot point of the mast and is fixed. P2 is the attachment of the cylinders onto the mast and rotates about P1. L represents the length of the cylinder and shaft at any time. An equation for the torque developed by the cylinders may be derived which is a function of the angle 3. The angle 3 is a direct function of the mast displacement angle 4.

$$P_2(x) = 1.183 + 3.982 \cos = L \sin \theta$$

$$P_2(y) = 7.454 + 3.982 \sin = L \cos \theta$$

$$L = \frac{1.183 + 3.982 \cos \beta}{\sin \theta} = \frac{7.454 + 3.982 \sin \beta}{\cos \theta}$$
(8-2)

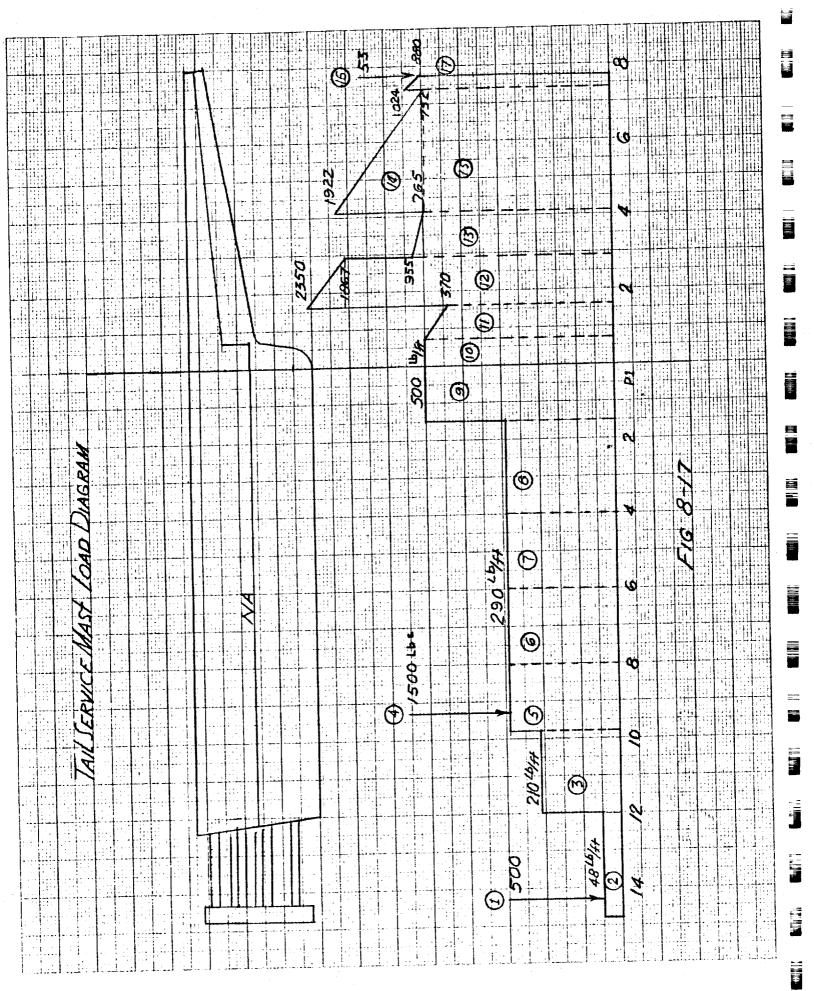
1.183 + 3.982
$$\cos \theta = \tan \theta \ (7.454 + 3.982 \sin \theta)$$

$$\theta = Arctan \frac{1.183 + 3.982 \cos \Theta}{7.454 + 3.982 \sin \Theta}$$
 (8-3)

$$T = (F \cdot \cos \theta)(3.982 \cos \theta) - (F \cdot \sin \theta)(3.982 \sin \theta)$$

$$T = 3.982 F \cdot (\cos \theta \cos \theta - \sin \theta)$$

$$T = 3.982 \text{ F} \cdot \cos (\theta + \Theta)$$
 (8-4)



TAIL SERVICE MAST MOMENT BY SECTION

REF FIG 8-17

W = weight of section

 $\overline{\mathbf{r}} = \mathbf{distance}$ to C G of section

d = distance to centerline of section

d= angular acceleration of mast

M = mass of section

| SEC | W | Ŧ | Wxd | Mr ² | |
|------|---------|------|-----------|-----------------|--|
| | 1bs | ft | ft-1b | ft-1b | |
| 1 | 500 | 14.3 | 1150 | 6350.62 | |
| 2 | 134.4 | 13.4 | 1800.96 | 1498.94 | |
| 3 | 462 | 11 | 5035.8 | 3472.17 | |
| 4 | 1500 | 9.3 | 13950 | 8058.07 | |
| 5 | 522 | 9.06 | 4645.8 | 2661.34 | |
| 6 | 580 | 7.08 | 4060 | 1805.8 | |
| 7 | 580 | 5.1 | 2900 | 937 | |
| 8 | 725 | 2.94 | 1993.75 | 389.23 | |
| 9 | 750 | 1.25 | 562.5 | 72.79 | |
| 10 | 350 | 1.38 | -122.5 | 41.4 | |
| 11 | 391.5 | 2.3 | -450.23 | 128.64 | |
| 12 | 2740.6 | 3.01 | -6166.35 | 1542.24 | |
| 13 | 1032 | 4.07 | -3612 | 1061.8 | |
| 14 | 1930.5 | 5.52 | -10038.6 | 3653.61 | |
| 15 | 2481.6 | 5.92 | -12159.84 | 5401.93 | |
| 16 | 53 | 8.38 | -408.1 | 231.17 | |
| 17 | 285.6 | 8.10 | -2156.28 | 1163.86 | |
| TOT. | 15018.2 | | 6984.91 | 38470.61 | |

TORQUE REQUIRED TO BALANCE = 45455.52 FT-LB

The unbalanced moment determined includes only that which is required to operate the mast and does not include any additional moment for operation of the hood. In order to determine what additional moment will be required for operation of the hood the system is made general. The hood motor system consist of two master actuators attached to the pivot point of the mast driving two slave actuators attached to each side of the hood. In this manner the inertial forces of one half are partially opposing those of the other half thereby requiring less driving force.

There is a pressure release valve between the input and output of the master actuator set to operate at a pressure above that which should be required for driving the slave units. Since the master actuator will have an output of approximately four times that required to operate the slave unit the relief valve will be open during closing of the hood. If the same pressure for opening of the relief valve is used as a back pressure on the master actuator a means for determining the torque required for the hood motor system is available. In the calculations for the torque a pressure of 2000 lbs/in² was used. The cam valve for the hood system opens at approximately 26°. Below this value negligible torque is required.

The initial force on the pistons may now be calculated. In order to determine the force on the piston throughout the stroke the torque, which is dependent upon the angular acceleration, must also be known. The summation of the inertial moments acting on the system may be set equal to the product of the moment of inertia and the angular acceleration thereby obtaining a constant for simplification of caluclations.

From equation 8-4 the force on the cylinders

$$F = \frac{T}{3.982 \cos (\theta + 3)}$$

For the initial force on the cylinders:

$$F = \frac{45455.52 \text{ ft-1b}}{3.982 \text{ ft. } \cos(49.3)} = 17506 \text{ lbs}$$

to determine the constant from $T = I \propto$ (8-5)

$$I = \frac{T}{Q} = \frac{45455.52 \text{ ft-1b}}{2 \text{ rad/sec}^2} = 22727.76 \text{ ft-1b-sec}^2$$

where ais the angular acceleration.

The following curves and tables show the force and torque required of the cylinders throughout their operating range. It may be noted here that with the hood system beginning operation just before the mast would start deceleration makes the compressive load on the cylinders occur at a shorter length.

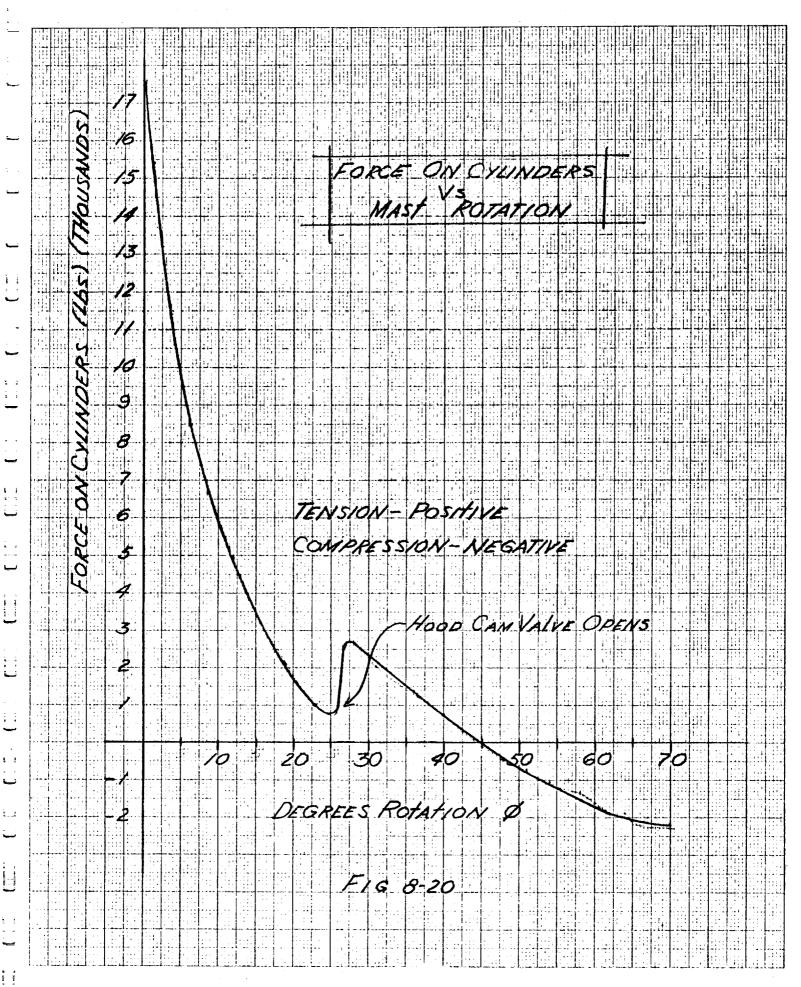
The pressure required on the cylinders is calculated in the next section.

The hood was still in the design stage and the weight used for calculation purposes may differ from that found elsewhere in this manual.

T= Torque required without hood $T_h=$ torque imposed upon system by hood $T_t=$ Total torque required F= total force required by cylinders

| Ø | G | θ | T | $T_{\mathbf{h}}$ | Tt | F |
|------|-------|------|--------|------------------|-------|-------|
| DEG | DEG | DEG | FT-LB | FT-LB | FT-LB | LB |
| 0 | 20.2 | 29.1 | O | " • | 0 | 0 |
| 0 | 20.2 | 29.1 | 45456 | | 45456 | 17506 |
| 1.5 | 18.7 | 29.6 | 40910 | 1 | 40910 | 15445 |
| 3.6 | 16.6 | 30.2 | 31819 | \ | 31819 | 11674 |
| 6.0 | 14.2 | 30.9 | 23864 | \ | 23864 | 8490 |
| 8.5 | 11.7 | 31.6 | 19319 | } | 19319 | 6666 |
| 12.0 | 8.2 | 32.6 | 14773 | | 14773 | 4906 |
| 15.0 | 5.2 | 33.4 | 10228 | | 10228 | 3287 |
| 19.0 | 1.2 | 34.4 | 6818 | (| 6818 | 2106 |
| 23.0 | -2.8 | 35.4 | 3409 | \ | 3409 | 1016 |
| 27.5 | -7.3 | 36.4 | 1136 | 8333 | 9469 | 2721 |
| 31.5 | -11.3 | 37.3 | -1136 | 1 | 7197 | 2011 |
| 36.0 | -15.8 | 38.2 | -3409 | . <u>1</u> | 4924 | 1338 |
| 40.0 | -19.8 | 38.9 | -5682 | 1 | 2650 | 704 |
| 44.0 | -23.8 | 39.5 | -7955 | / | 378 | 98.6 |
| 48.0 | -27.8 | 40.1 | -10228 | / | -1895 | -487 |
| 51.0 | -30.8 | 40.4 | -11364 | - 1 | -3031 | -772 |
| 54.5 | -34.3 | 41.5 | -12500 | (| -4167 | -1055 |
| 57.5 | -37.3 | 40.5 | -13637 | \ ' | -5304 | -1334 |
| 60.0 | -39.8 | 40.9 | -14773 | | -6440 | -1618 |
| 62.0 | -41.8 | 40.9 | -15910 | 1 | -7577 | -1903 |
| 63.7 | -43.5 | 40.8 | -15910 |) | -7577 | -1905 |
| 65.0 | -44.8 | 40.8 | -17046 | V | -8713 | -2193 |
| 70.0 | -49.8 | 40.4 | -17046 | ı | -8713 | -2218 |

F16 8-19



C. HYDRAULICS. From the previous section the total force on the cylinders to give the mast an acceleration of 2 rad/sec² was 17506 lbs. Since there are two cylinders the force on one cylinder will be 8753 lbs.

To find the pressure required on the piston let P_n be the pressure on the input side of the cylinder and P_0 be the pressure on the output side, then $P_n - P_0$ will be the pressure differential across the piston (+ sign to coincide to the force applied with + sign indicating cylinder shaft in tension).

 P_n will remain constant except for the pressure drop due to the increase in volume of the input side. The increase in volume and consequently the decrease in pressure on the input side of the cylinder may be determined by multiplying the displacement of the piston by the area on the input side. The input pressure P_n will be dependent only upon that which is available at the accumulator and will be given at any time by:

The output pressure P_0 will in part be determined by P_n and in part by the pressure build-up due to the orifice of the control valve. Since the force required upon the piston is known, the input pressure required may be determined by:

$$P_n A_n - P_o A_o = F (8-7)$$

Where: $P_0 = sum of pressures on the output side.$

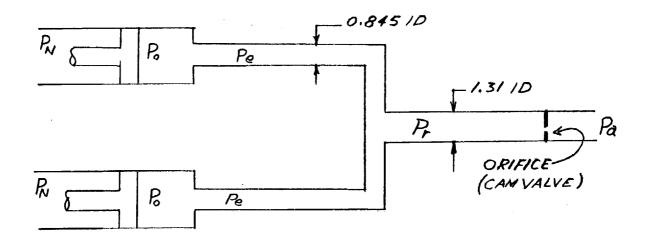


FIG 8-21

The total output pressure may be analyzed by the summation of all the pressures downstream of the piston. The pressure drop in the lines may be assumed to approach zero due to the small value of the total length and the dynamic viscosity μ in the line drop equation 32μ VL/D² where μ is on the order of 10^{-5} . Then P_0 becomes $P_a + P_r + P_e$. The pressure drop across the orifice $P_r - P_a$ will be dependent upon the flow through the cam valve. To simplify the calculations the two cylinders may be taken as one with the equivalent area.

For the initial conditions assume the valve is open and the orifice will be the same diameter as the outlet. Figure 8-20 is a general schematic of the hydraulic system. The areas shown represent the total areas for the two cylinders. The orifice is indicated as discharging directly into the atmosphere.

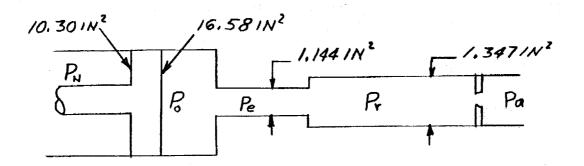


FIG 8-22

$$P_{o} = (P_{o} - P_{e}) + (P_{e} - P_{r}) + (P_{r} - P_{a}) + P_{a}$$

$$P_{o} = \frac{1}{2} \rho (v_{e}^{2} - v_{o}^{2}) + \frac{1}{2} \rho (v_{r}^{2} - v_{e}^{2}) + P_{a}$$

$$P_{o} = \frac{1}{2} Q^{2} \rho (1/A_{e}^{2} - 1/A_{o}^{2}) + \frac{1}{2} Q^{2} \rho (1/A_{r}^{2} = 1/A_{e}^{2}) + P_{a}$$

$$P_{o} = \frac{1}{2} Q^{2} \rho (1/A_{r}^{2} - 1/A_{o}^{2}) + P_{a}$$

$$(8-9)$$

The additional pressure needed to overcome the inertia of the fluid is relatively small as shown for the initial flow of 170.8 in^3/sec .

From:
$$F = Q P (\Delta V)$$

for an initial velocity of 14 in/sec
 $F = (170.8 \text{ in}^3/\text{sec}) (8.023 \times 10^{-5} \text{lb-sec}^2/\text{in}^4) (14 \text{ in/sec})$
 $F = 0.192 \text{ lbs}$

Additional pressure needed: $P=0.192~lbs/16.58~in^2=0.013~lbs/in^2$ This is small in comparision to the total pressures needed and can be neglected.

In order to determine the initial input pressure the initial output pressure must be determined. This output pressure will be the sum of the pressure drops plus atmospheric pressure indicated in equation 8-8 as $P_{\rm a}$.

$$P = \frac{1}{2}(170.8 \text{ in}^3/\text{sec})^2 (8.023 \times 10^{-5}1\text{bs-sec}^2/\text{in}^4) (0.551 - 0.004 \text{ in}^2) + 14.7 \text{ lb/in}^2$$

$$P_o = 15 \text{ lb/in}^2$$

The input pressure is then:

$$P = \frac{P_0 A_0 + F}{A_n} = \frac{(15)(16.58) + 17.5K}{10.3} = 1724 \text{ lb/in}^2$$

From this initial input pressure the remaining values of P_n may be calculated from equation 8-6 and the required value of the output pressure may be determined throughout the operating range.

As an example from figure 8-18 and 8-21 at $\emptyset = 3.6^{\circ}$

$$Q_0 = 185.7 \text{ in}^3/\text{sec}$$

$$P_n = 1692 \text{ lb/in}^2$$

$$F = 11674$$

) ;;;;

$$P_0 = \frac{P_n A_n - F}{A_0} = \frac{(1692)(10.3) - 11674}{16.58} = 347 \text{ lb/in}^2$$

From equation 8-8 the pressure drop across the orifice will not be equal to zero and:

$$(P_r - P_a) = P_o - 1/2Q^2 (1/\Lambda_r^2 - 1/\Lambda_r^2) - P_a$$
 (8-10)

The areas $\Lambda_{\mathbf{r}}$ and $\Lambda_{\mathbf{0}}$ and the density are constant therefore the pressure drop may be determined in terms of the flow Q.

$$(P_r - P_a) = P_a - (2.74 \times 10^{-5}) Q^2 - 14.7$$

 $(P_r - P_a) = 347 - (2.74 \times 10^{-5})(185.7)^2 - 14.7$
 $(P_r - P_a) = 331.4 \text{ lb/in}^2$

The pressure drop required across the orifice (cam valve) can be calculated using equation 8-10. From actual test data on the cam valve a flow of 100 gal/min gave a pressure drop of 800 lbs/in² for a diameter of 0.380 inch. This data was used to determine the diameter at other flows and pressures assuming a constant coefficient of discharge. This method will provide for a preliminary design for the mast control cam.

Curves have been made to indicate the flow on both the input and output side of the cylinders. The flow is necessarily high but occurs over a short period of time and should cause no malfunction of components.

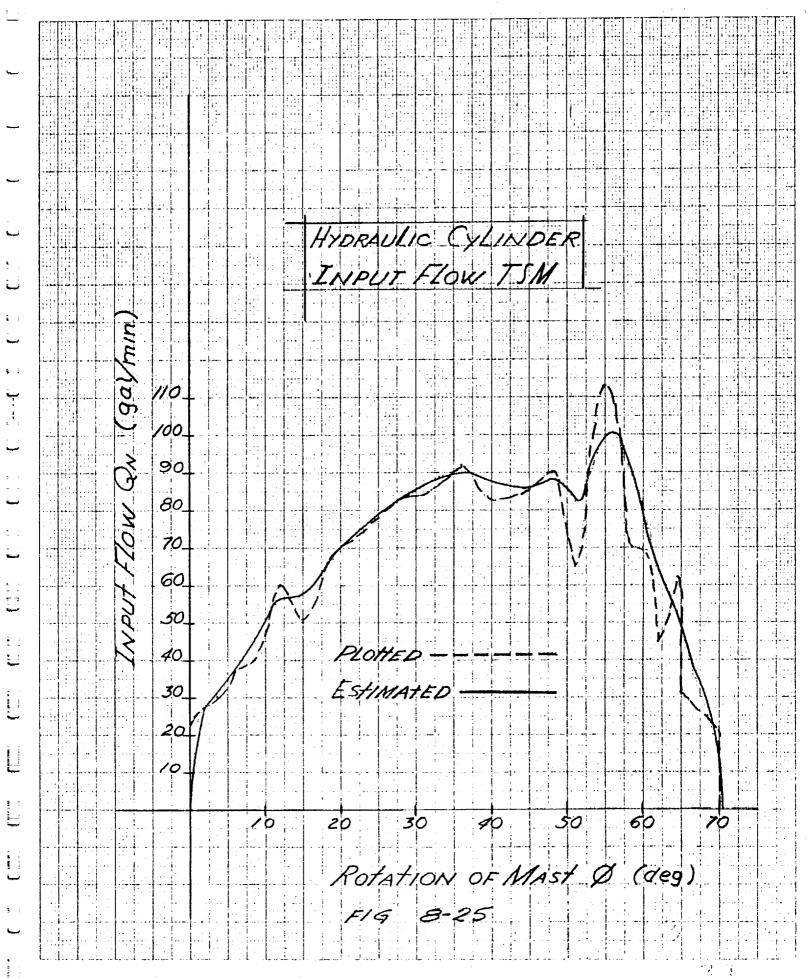
| Ø | L | ΔL | Δv_n | (| \mathbb{Q}_{n} | ΔV_o | Q | (I) |
|------|--------|------|-----------------|----------------------|------------------|-----------------|----------------------|---------|
| Deg | in | in | in ³ | in ³ /sec | gal/min | in ³ | in ³ /sec | gal/min |
| 0 | 121.41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.5 | 120.38 | 1.03 | 10.6 | 106 | 27.53 | 17.08 | 170.8 | 44.36 |
| 3.6 | 119.26 | 1.12 | 11.54 | 115.4 | 29.97 | 18.57 | 185.7 | 48.23 |
| 6.0 | 117.85 | 1.41 | 14.52 | 145.2 | 37.71 | 23.38 | 233.8 | 60.72 |
| 8.5 | 116.39 | 1.46 | 15.04 | 150.4 | 40.0 | 24.21 | 242.1 | 62.87 |
| 12.0 | 114.13 | 2.26 | 23.28 | 232.8 | 60.46 | 37.47 | 374.7 | 97.31 |
| 15.0 | 112.23 | 1.90 | 19.57 | 195.7 | 50.82 | 31.5 | 315.0 | 81.81 |
| 19.0 | 109.68 | 2.55 | 26.27 | 262.7 | 68.22 | 42.28 | 422.8 | 109.8 |
| 23.0 | 106.89 | 2.79 | 28.74 | 287.4 | 74.64 | 46.26 | 462.6 | 120.14 |
| 27.5 | 103.80 | 3.09 | 31.83 | 318.3 | 82.66 | 51.23 | 512.3 | 133.04 |
| 31.5 | 100.75 | 3.15 | 32.45 | 324.5 | 84.27 | 52.23 | 522.3 | 135.64 |
| 36.0 | 97.31 | 3.44 | 35.43 | 354.3 | 92.01 | 57.04 | 570.4 | 148.13 |
| 40.0 | 94.20 | 3.11 | 32.03 | 320.3 | 83.18 | 51.56 | 515.6 | 133.90 |
| 44.0 | 91.05 | 3.15 | 32.45 | 324.5 | 84.27 | 52.23 | 522.3 | 135.64 |
| 48.0 | 87.67 | 3.38 | 34.81 | 348.1 | 90.40 | 56.04 | 560.4 | 145.54 |
| 51.0 | 85.24 | 2.43 | 25.03 | 250.3 | 65.00 | 40.29 | 402.9 | 104.63 |
| 54.5 | 81.00 | 2.43 | 43.67 | 436.7 | 113.41 | 70.30 | 703.0 | 182.57 |
| 57.5 | 78.39 | 2.61 | 26.88 | 268.8 | 70.0 | 43.27 | 432.7 | 112.38 |
| 60.0 | 77.76 | 2.63 | 27.09 | 270.9 | 70.35 | 43.61 | 436.1 | 113.26 |
| 62.0 | 76.09 | 1.67 | 17.20 | 172.0 | 44.67 | 27.69 | 276.9 | 71.91 |
| 63.7 | 74.78 | 2.31 | 23.79 | 237.9 | 61.78 | 38.30 | 383.0 | 99.47 |
| 65.0 | 73.62 | 1.16 | 11.95 | 119.5 | 31.03 | 19.23 | 192.3 | 49.94 |
| 70.0 | 69.50 | 4.12 | 42.44 | 84.9 | 22.05 | 68.31 | 136.6 | 177.4 |

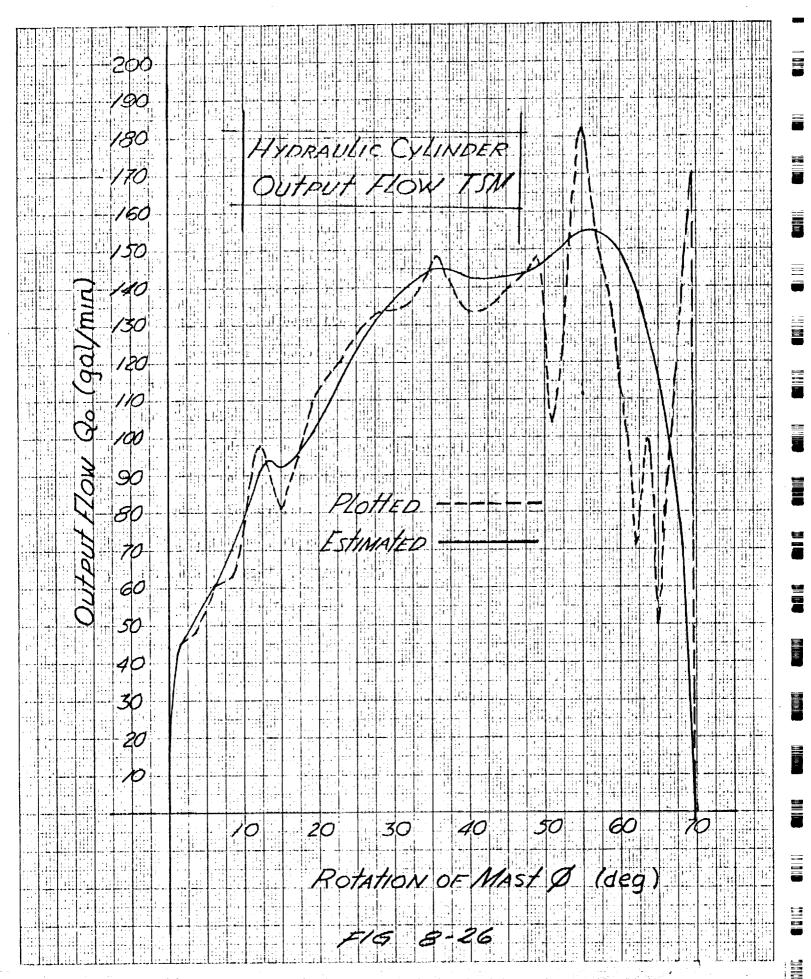
① For two cylinders

| ø | S | $\mathbf{\Omega}_{\mathbf{p}}$ | P _n ② | Po | P _r - P _a | d |
|------|-------|--------------------------------|--------------------|--------------------|---------------------------------|-------------|
| Deg | in | in ³ | lb/in ² | 1b/in ² | lb/in ² | ORIFICE DIA |
| 0 | 0 | 0 | 1724 | 1724 | 0 | |
| 1.5 | 1.03 | 10.6 | 1708 | 130 | 115 | 0.81 |
| 3.6 | 2.15 | 22.15 | 1692 | 347 | 332 | 0.65 |
| 6.0 | 3.56 | 36.67 | 1671 | 526 | 511 | 0.65 |
| 8.5 | 5.02 | 51.71 | 1650 | 623 | 608 | 0.63 |
| 12.0 | 7.11 | 73.23 | 1621 | 711 | 696 | 0.75 |
| 15.0 | 9.18 | 94.55 | 1594 | 792 | 777 | 0.68 |
| 19.0 | 11.73 | 120.82 | 1561 | 843 | 828 | 0.78 |
| 23.0 | 14.52 | 149.56 | 1526 | 887 | 872 | 0.80 |
| 27.5 | 17.61 | 181.38 | 1490 | 762 | 747 | 0.87 |
| 31.5 | 20.66 | 212.80 | 1456 | 783 | 768 | 0.87 |
| 36.0 | 24.10 | 248.23 | 1419 | 801 | 886 | 0.88 |
| 40.0 | 27.21 | 280.26 | 1387 | 819 | 804 | 0.86 |
| 44.0 | 30.36 | 312,71 | 1357 | 837 | 822 | 0.86 |
| 48.0 | 33.74 | 347.52 | 1325 | 853 | 838 | 0.89 |
| 51.0 | 36.17 | 372.55 | 1304 | 857 | 842 | 0.75 |
| 54.5 | 40.41 | 416.22 | 1267 | 851 | 836 | 1.0 |
| 57.5 | 43.02 | 443.10 | 1246 | 855 | 840 | 0.78 |
| 60.0 | 43.65 | 449.60 | 1241 | 869 | 854 | 0.78 |
| 62.0 | 45.32 | 466.80 | 1228 | 878 | 863 | 0.62 |
| 63.7 | 46.63 | 480.29 | 1218 | 872 | 857 | 0.73 |
| 65.0 | 47.79 | 492.24 | 1209 | 883 | 868 | 0.52 |
| 70.0 | 51.91 | 534.67 | 1178 | 866 | 851 | 0.44 |

For two cylinders

Based upon an accumulator volume of 1155 in³ and an initial pressure of 1724 lbs/in²





- E modulus of elasticity (lb/in²)
- f frequency of vibration (sec⁻¹)
- g acceleration of gravity (32.2 ft/sec 2 , 386 in/sec 2)
- I area moment of inertia (in^4)
- L intensity level (decibel)
- L length of assumed beam (in,ft)
- P sound pressure (dynes/cm², $1b/in^2$)
- 凡 plate
- W total weight
- x horizontal distance from pivot of mast (in,ft)
- X(x) amplitude as a function of x
- Y deflection in vertical (in)
- y velocity (in/sec, ft/sec)
- y acceleration $(in/sec^2 ft/sec^2)$
- Ø angular velocity (rad/sec)

8-2 VIBRATION ANALYSIS

A. GENERAL During firing of the Saturn V vehicle intense mechanical and acoustical vibration in the Tail Service Mast area will be experienced.

Certain stresses in addition to those set up by the temperature, pressure, and exhaust impingement of the Saturn V engines will exist. These stresses will have as the excitation source acoustic and mechanical vibration.

Vibration whether acoustic or mechanical, is either sinusoidal or random in nature. Sinusoidal vibration would represent a single point source vibrating at one frequency giving rise to a periodic or harmonic waveform. Random vibration, as opposed to sinusoidal, is a group of frequencies usually having a broad peak within a certain frequency range. For instance rocket engine noise is random having a single broad peak in the audible frequency range. The frequency at which the spectrum reaches a maximum increases as the nozzle exit velocity increases.

In a rocket engine the sound pressure levels are high enough to cause structural and equipment damage up to distances of 100 times the nozzle diameter. The acoustic power level is proportional to the total power output of the jet exhaust with maximum efficiency occurring at the higher exhaust gas temperatures. 1

Vibration damage is usually a result of fatigue cracks occuring in the structure. Since the vibration, acoustical and mechanical, will be of short duration during Saturn V launch the Tail Service Mast is not expected to undergo severe damage. However, since such a high intensity level for the Tail Service Mast area has been predicted items such as hydraulic lines, electrical connections, conduits, brackets, etc. are susceptible to failure.

The manner in which any structure responds to acoustic excitation is dependent upon the intensity of the field and the design characteristics of the structure. The Tail Service Mast, being massive, will not be very sensitive to the acoustic field. Due to the design of the mast, however, the area near the pivot point will experience considerable stresses. The mounting manner of the Tail Service Mast approximates a beam on a tower or a cantilever beam which will result in low frequency, high amplitude oscillations. These mounting methods often lead to structural failure.

For a general vibration analysis of the Tail Service Mast it may be assumed to react as though it were a beam supported either at one end or at the middle and one other point. Since the mast changes cross section at approximately the pivot point and becomes quite massive for the counterweight section the basic mast may be approximated by a cantilever beam.

A complete vibration study of the Tail Service Mast will not be possible except under actual operating conditions. It will, however, be within the scope of this report to obtain an approximate value for these additional stresses and to show that the Tail Service Mast as designed will withstand these stresses.

To make a general vibration analysis of the Tail Service Mast the following assumptions will be made:

- The vibration of the Tail Service Mast can be expressed as a sinusoidal function.
- 2. The Tail Service Mast will react to the vibration influences as though it were a cantilever beam.
- 3. The hood in the open position will be considered negligible as a secondary source of vibration with respect to the basic structure.
- 4. The counterweight section of the mast will have infinite mass and therefore be insensitive to vibration.

In order to determine the additional stresses the mast will be subjected to due to the acoustical field an intensity level of 190 db from reference 4 will be used. For the acoustic pressure all other forces acting on the mast will be taken as negligible. The deflection of the mast due to the weight and concentrated load of the hood will be neglected in order to observe the effects of the acoustic pressure.

Wave energy passes through an area with a rate that is proportional to the energy density and the velocity of the wave. This rate is the intensity of the wave. The intensity level for the Saturn V launch may be calculated as approximately 190 db in the Tail Service Mast area.⁵

The intensity level is given by 2

$$L = 20 \text{ Log } \frac{P}{Po} \text{ where Po} = 2 \text{ x 10-4 dynes/cm}^2$$
 (8-11)

from this then $P = Po (10)^{L/20}$ and for a level of 190 db

$$P = (2 \times 10^{-4}) (10)^{9.5} = 2 \times 10^{5.5} (dynes/cm^2)$$

$$P = 6.32 \times 10^5 \text{ dynes/cm}^2$$

6.32 x
$$10^5$$
 dynes/cm² x $\frac{14.5 \times 10^{-6} \text{lbs/in}^2}{1 \text{ dyne/cm}^2} = 9.17 \text{ lbs/in}^2$

For a 32 inch wide beam this is a uniform load of 293.4 lb/in. The mast will be considered as a cantilever beam with a constant pressure loading.

The shape of a uniformly loaded cantilever beam may be taken as

E I
$$y = \frac{wx^2}{24}$$
 (6L² - 4Lx + x²) (8-12)

This then will also be the shape of the load factor curve in order to determine the shear and moment on the Tail Service Mast.

The cross sectional area of the Tail Service Mast changes due to the stiffeners, etc. and any attempt to determine the area moment of inertia of all cross sections would be quite cumbersome. It will, therefore, be necessary to assume a constant cross section having an average of the values taken from various sections.

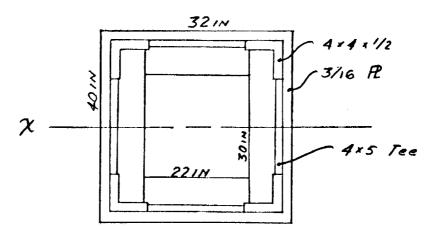


Fig 8-27 Cross section of mast through stiffeners

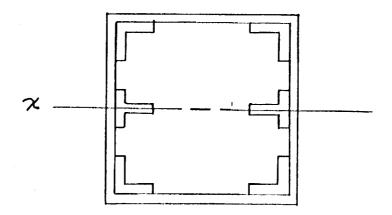


Fig 8-28 Cross section of mast without stiffeners

The stiffeners, plates and panels will be assumed welded close enough to take the area moment of inertia as the difference in the two rectangles as shown in Figures 8-27 and 8-28.

$$I = \frac{32 \times 40^3 - 22 \times 30^3 \text{ (in)}^4}{12}$$

$$I = 1.2 \times 10^5 \text{ in}^4$$

$$I' = \frac{(32) (40)^3 - (31.6) (39.6)^3 + 2(3.36) + \boxed{5.6 + 3.75 (18)^2} 4$$

$$1! = 1.2 \times 10^4 \text{ in}^4$$

Take as the I for any cross section the average of I and I' which is

$$\bar{I} = 6.65 \times 10^4 \text{ in}^4$$

If this average I and the loading of 293,4 lb/in is substituted into equation 8-12 the shape of the beam due to the acoustic pressure will then be given by:

$$y = x^2(6L^2 - 4Lx + x^2) (6.12 \times 10^{-12})$$

The acceleration in G's will be proportional to the displacement of of the beam and therefore the load factor curve will have the same shape given by equation 8-12. At x=0 the displacement y=0 and consequently the acceleration y=0. At x=L the displacement y=0 will have a maximum value and therefore the acceleration will be at a maximum for any period of vibration.

Since the weight of the mast has been neglected for the acoustical loading the maximum displacement or amplitude of any portion of the mast will be given by equation 8-12.

For the maximum displacement : x = L and

$$y = \frac{W L^4}{8 E I}$$

$$y + 18.38 \times 10^{-12} (154)^4 \text{ in}$$

$$y = 0.01 \text{ in}$$

The amplitude or X(x) will at any time be dependent upon the frequency of the applied sound pressure with a maximum occurring at resonance. The greatest stress the mast will be subjected to will occur then at resonance.

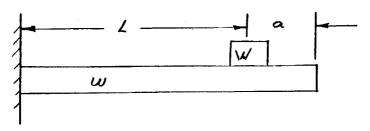


Fig 8-29 TSM represented as a cantilever beam

The hood will be considered as a concentrated weight near themendeof the mast as shown in figure 8-29.

The natural frequency of the first mode of vibration for a cantilever beam:

$$f_b = \frac{3.5}{2\pi(L+a)^2} - \sqrt{\frac{E I g}{w}}$$

and for a mass vibrating on the end of a weightless cantilever beam:

$$f_{\rm m} = \frac{1}{277} - \sqrt{\frac{3 \ E \ \overline{1} \ g}{w \ L^3}}$$

The resonant frequencies of the two independent systems may be combined for an approximate resonance of the entire system by:

$$\frac{1}{f_n^2} = \frac{1}{f_b^2} + \frac{1}{f_w^2}$$

$$\frac{1}{f_n^2} = \frac{w(2\pi) (L + a)}{(3.5)^2 (E I g)} + \frac{w(2\pi) L}{(E I g)}$$

$$f_n = \frac{3.5}{2\pi} \sqrt{\frac{3 E \overline{I} g}{3w (L + a)^4 + 12.25 WL^3}}$$

$$f_n = \frac{3.5}{2\pi} \sqrt{\frac{3(30 \times 10 \text{ lbs/in}^2) \cdot (6.65 \times 10^4 \text{in}^4) \cdot (386 \text{ in/sec}^2)}{3(21 \text{ lb/in}) \cdot (144 \text{ in})^4 + 12.25 (1400 \text{ lbs}) \cdot (110 \text{ in})^3}}$$

$$f_n = \frac{3.5}{2\pi} - \sqrt{\frac{23.1 \times 10^{14}}{270 \times 10^8 + 228 \times 10^8}} = 113 \text{ cps}$$

The resonant frequency of the system is well within that range where most damage will occur. Low frequency high amplitude oscillations often lead to structural failure. The Saturn V launch will be prominent in the frequency range of 80 to 2000 cycles per second.

It can be shown that during resonance the amplitude of a vibrating specimen will exceed the amplitude of the specimen under the same load at any other frequency.

If y represents a harmonically varying function such as X(x) sin \emptyset t then the acceleration \mathring{y} may be found for any portion of the vibrating mast at its worst or fundamental frequency.

$$y = X(x) \sin \theta t$$

$$\dot{y} = X(x) \theta \cos \theta t$$

$$\ddot{y} = X(x) \theta^{2} \sin \theta t$$

$$(8-16)$$

$$\ddot{y} = X(x) \theta \cos \theta t$$

$$(8-17)$$

$$\text{where } \theta = 2\pi f$$

The acceleration predicted for the Tail Service Mast area is 100 G(rms)⁵. This is the acceleration that a 3 x 3 foot plate would experience at the center and would have to be corrected by a weight and frequency factor in order to have significance for the Tail Service Mast. If the cantilever beam method is used, however, the acceleration may be determined directly by equation 8-17.

At resonance y will have a maximum value where $\sin \phi t = 1$. If X(x) then is set equal to y max then the acceleration

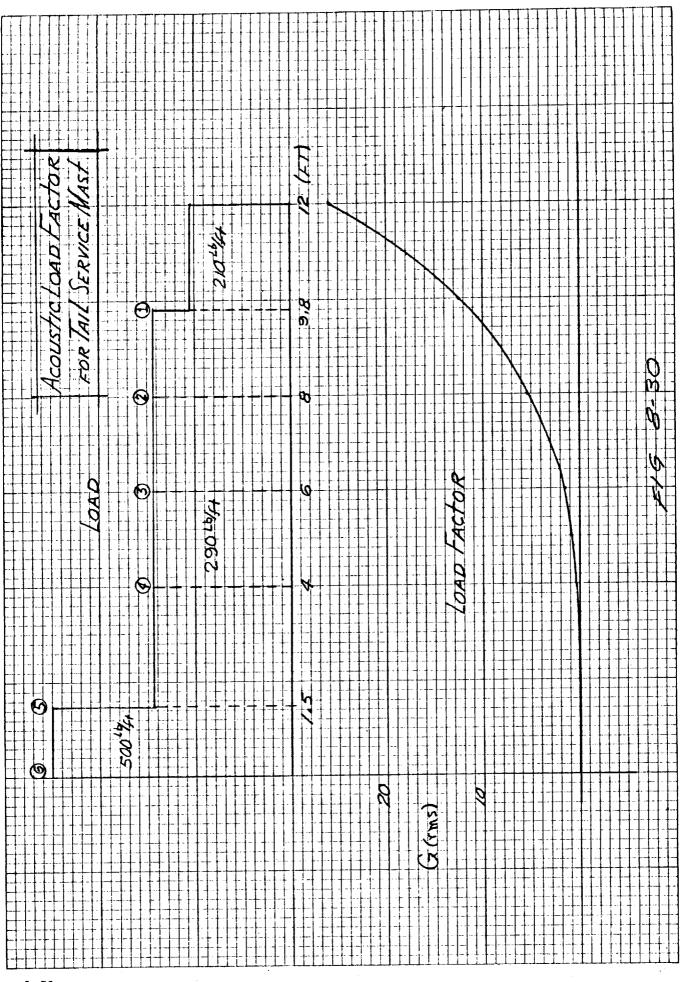
$$\ddot{y} = -(0.01)(2 \ 113)^2 = -5041 \ in/sec^2$$

The minus sign is insignificant for the load and in terms of gravitational units:

$$\dot{y} = \frac{5041}{386} = 13 \text{ G}$$

This is the maximum acceleration attained by the beam or mast at $\mathbf{x} = \mathbf{L}$ and the value of G will be proportional to \mathbf{L}^4 . The load produced by the acoustic pressure will produce stress reversals in a relatively short time (on the order of 0.088 seconds at resonant frequency) and would be considered as a suddenly applied load. It will be necessary then to multiply the load by the factor of two for impact. In the load curve the maximum acceleration used was 26 Gs instead of 13 G.

The maximum stress due to the bending moment will be at the position where the mast abruptly changes cross section near the pivot point. If the minimum moment of inertia is used the stress will be given by MC/I where C is the distance to the neutral axis taken as 20 inches for the mast.



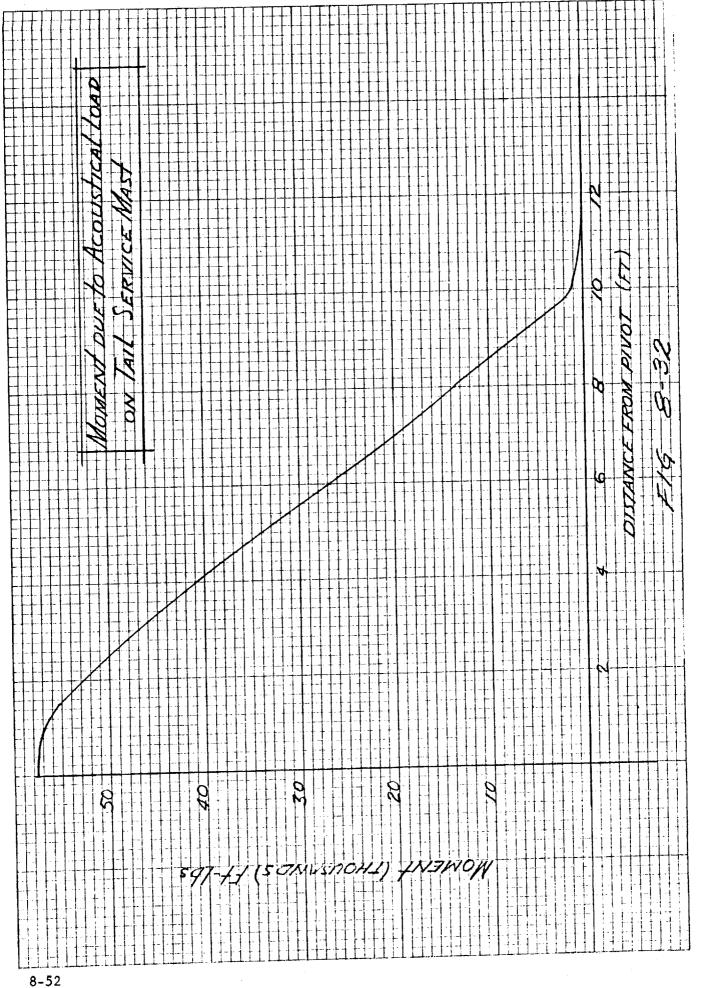
ii ii

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畫畫

I

| AR DUE TO ACOUSTICAL LOAD OK LAIL SERVICE MAST | | | 10 12 21/207 (E7) |
|---|-------------|---------|--------------------------------------|
| Shear Due to Acoustical | | | VSIAWE EROM PIVOT (ET) 1 F19 8-31 |
| | | | 7 |
| 597 | (SONVS/SON) | \$ b7/5 | |



For the stress at a cross section 1.5 feet foward of the pivot point C = 20 in and $I = 1.2 \times 10^4$ in⁴.

The stress $\sigma = MC/I$

$$\sigma = \frac{(55000 \times 12 \text{in} - 1b)(20 \text{ in})}{1.2 \times 10^4 \text{in}^4} = 1100 \text{ lbs/in}^2$$

This additional stress will not affect the structure of the mast, however, items carried within the mast particularly at the forward end are susceptible to failure. Items such as brackets, clamps, relays, solenoids and analagous designs should be positioned and isolated for least vibratory effects.

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- 3. W. T. Thompson: Mechanical Vibrations, 2nd edition, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1953.
- 4. Vibration Level Memorandum #34-63 R-P & VE-SVE MSFC 22 November 1963.
- 5. Launch Complex #39 Shock and Vibration Environments and Test Specification Levels of Ground Support Equipment. LOC Preliminary release (No date).
- 6. F. L. Singer: Strength of Materials. Harper & Brothers, Publishers, New York, N. Y., 1951.

8-3 STRESS ANALYSIS

The stress analysis covers in detail the fabricating and structual members of the Tail Service Mast. The design of the mast at the time of analysis was still in the preliminary stage and some components may be different than those analyzed. Changes that affected the structure stress-wise were checked against existing components and where found to exceed those requirements were not necessarily incorporated into the analysis.

Weights and forces on some components have changed and may not necessarily be the same as those used elsewhere in this manual. The stress analysis section will be revised as soon as design is finalized.

SHEAR REFERENCE MIL-HDBK-5 AUGUST 1962

1.4.6.3 Proportional Limit in Shear (Fsp). -- This property is of particular interest in connection with formulas which are based on considerations of perfect elasticity, as it represents the limiting value of shearing stress to which these formulas can be accurately applied. As previously noted, this property cannot be determined directly from torsion tests. The results of research at the National Bureau of Standards show that the ratio of the proportional limit in shear to the proportional limit in tension can be assumed to be approximately 0.55 for the commonly used materials.

- A AREA (SQ. IN.)
- C COMPRESSION (LBS, KIPS)
- F LOAD (CONCENTRATED) (LBS, KIPS)
- I AREA MOMENT OF INERTIA (IN4)
- K KIPS (1000 LBS.)
- M MOMENT, MASS (IN, LBS, FT, LBS)
- P REACTION (LBS, KIPS)
- R RESULTANT, LENGTH (LBS, KIPS, FT)
- s SECTION MODULUS (IN3)
- T TENSION (LBS, KIPS)
- V SHEAR (LBS, KIPS)
- W WEIGHT (LBS, KIPS)
- a RADIUS, ACCELERATION (IN, FT, FT/SEC²)
- d DISTANCE (IN)
- f STRESS (LBS, IN²)
- g ACCELERATION OF GRAVITY (FT/SEC/SEC)
- h HEIGHT OR DEPTH (IN, FT)
- 1 LENGTH (IN, FT)
- p UNIT PRESSURE (LBS/SQ, IN)
- r LENGHT (FT)
- t THICKNESS (IN)
- x COORDINATE (IN, FT)
- y COORDINATE (IN, FT)
- Z COORDINATE (IN, FT)

/ - COEFFICIENT OF FRICTION (UNITLESS)

- POUNDS

77 - CONSTANT (3.1416)

∠ - SUMMATION

Ø, O, B - ANGLE (DEGREES)

ABBREVIATIONS

a AT

.CG . CENTER OF GRAVITY

CONT CONTINUED

EA EACH

⊈ CENTER LINE

MIN MINIMUM

MAX MAXIMUM

PLATE

REQ'D REQUIRED

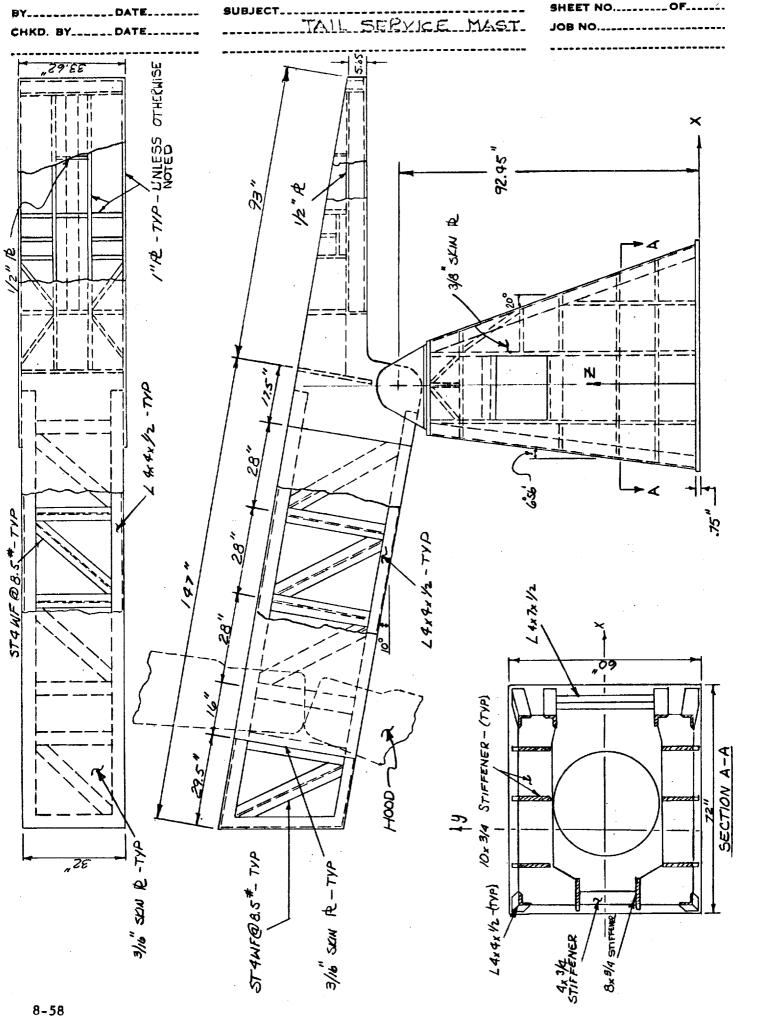
VERT VERTICAL

WT WT

% PERCENT

PERPENDICULAR

SQUARE INCHES



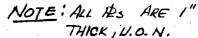
4-1" RS @ END OF TAIL SECTION = 4x5.65 x 40.8 = 77%

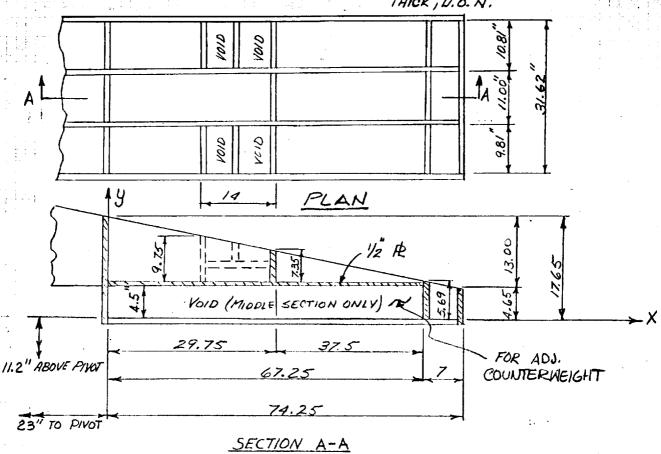
8-59

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| | The second secon | 7.77 | | | | | | , | |
| | 1.1 | _ | 4 | 9.79 | | | 4 | 7.75 | |
| | | | [WEIGHT | OF DYN | 9-THER | M | | _ | |
| | | 31 #/FT | | | | | | | 9.6 |
| | Track to the second seco | | | | | | #/ ** | rised an i | |

WT. OF DYNA-THERM PER SQ. FT. = $2.58 \, ^{\sharp}$ FT. 2 (BASED ON WET WEIGHT) 8.8 #/gal.*

* REF: DYNA-THERM CHEMICAL CORP.
100 W. ALAMEDA.
BURBANK, CALIFORNIA





WEIGHT OF LEAD = 687 LES./FT3

ADJUSTABLE COUNTERWEIGHTS

MAKE ADJ. COUNTERWEIGHTS 91/2" × 41/4" × 12"

WT. = 9.5 × 4.25 × 12 × 687 = 192 185.

| NO. | S/ZE | V (VOLUME) | × | Y | ∨ ∇ | VΣ |
|-----|------------------------------|------------|-------|-------|------------|---------|
| 2 | 15.75 × 9.81 (9.75 + 12.45) | 3460 | 7.54 | 10.63 | 26,088 | 36,780 |
| 1 | 10.00x28.75 (12.65+7.35) | 2875 | 13.10 | 10.12 | 37,663 | 29,095 |
| Ĺ | 10.00×37.5(7.35+.69) | 1507 | 42.25 | 7.45 | 63,670 | 11,227 |
| 2 | 37.50, 9.81 (12.35+5.69) | 6640 | 46.15 | 4.72 | 306,936 | 31,341 |
| 1 | 31.62 x 5 (5.69+4.65) | 818 | 70.67 | 2,59 | 57,808 | 2119 |
| | | | , | | | |
| | TOTAL | 15,300 | | | 491,665 | 110,562 |

CENTER OF GRAVITY FROM PIVOT

$$\overline{X}_p$$
= 23 + $\frac{491,665}{15,300}$ = 55.13"

$$\overline{Y}_p = 11.2 + \frac{1/0,562}{15,300} = 18.43$$

WEIGHT OF COUNTERWEIGHT

$$W = \frac{15,300 \times 687}{1728} = 6080^{\#}$$

MOMENT ABOUT PIVOT

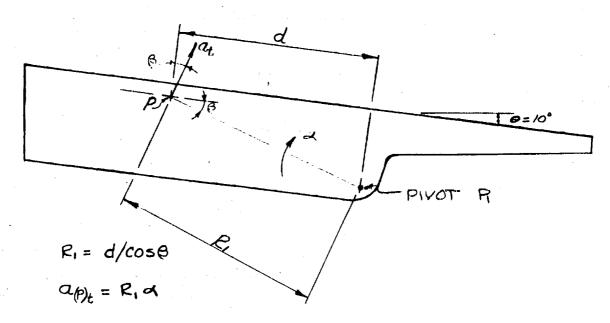
$$M = \frac{6080 \times 55.1}{12} = 28,000 FT - \#$$

BY_____DATE____ Chkd. By____ Date____

PER PENDICULAR TO TOP OF ARM TAIL SERVICE MAST

SHEET NO.....OF....

INITIAL ANGILLAR ACCELERATION & = 2 RADIANS



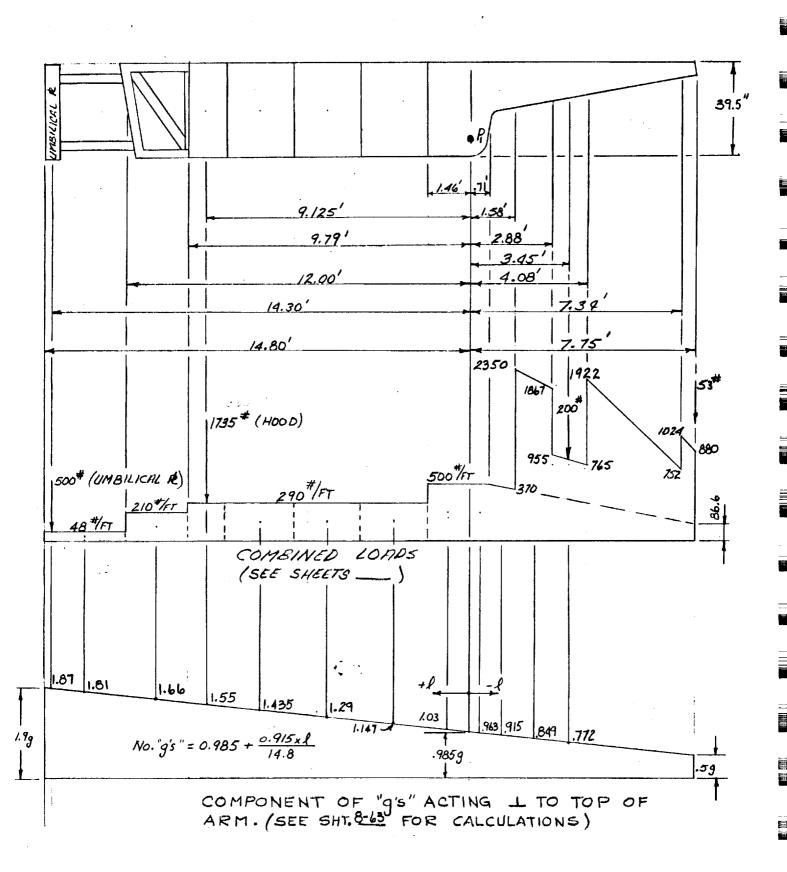
TO DETERMINE THAT COMPONENT OF ACCELERATION ACTING PERPENDICULAR TO TOP OF ARM, BREAK Qt INTO COMPONENTS PERPENDICULAR TO & PARALLEL WITH THE TOP OF ARM AT ANY POINT "P".

GRAVITATIONAL ACCELERATION IS ALSO BROKEN UP INTO COMPONENTS.

1 COMPONENT = 9 COS 10° = 0.9859 (ACTING ALL ALONG ARM)

THE "9" DIAGRAM SHOWN ON SHEET 8-64 IS THE SUM OF THE

| BYDATE | SUBJECT LOHD & "9" DIAGRAM | SHEET NO OF |
|--------|----------------------------|-------------|
| | TRIL SERVICE MAST | |
| | | |



" I I I I

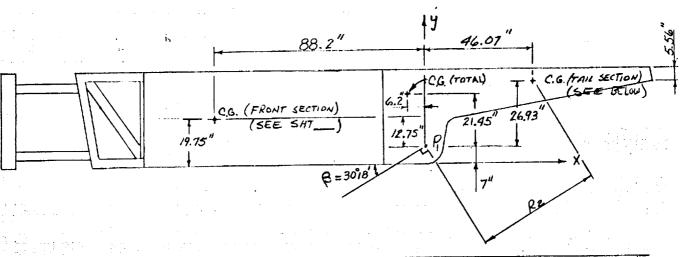
SEE SHEETS 8-64 FOR LOADS

Y (FRONT SECTION) = 19.75" (BY INSPECTION)

 $\overline{X} (FRONT SECTION) = \frac{\Sigma Wd}{\Sigma W}$ $\overline{X} = \frac{500 \times 14.3 + 48 \times \overline{14.8}^2 + 162 \times \overline{12}^2 + 80 \times \overline{9.79}^2 + 1735 \times 9.125 + 210 \times \overline{146}^2}{500 + 48 \times 14.8 + 162 \times 12 + 80 \times 9.79 + 1735 + 210 \times 1.46}$

 $\overline{X} = \frac{7150 + 5250 + 11,650 + 3830 + 15,820 + 224}{500 + 710 + 1950 + 783 + 1735 + 307}$

 $\overline{X} = \frac{43,924}{5985} = 7.35'$ OR 88.2" (SEE SKETCH, SHT. 8-66)



| ITEM | (WEIGHT) | \overline{X} | ア | WX | WV |
|--------------------|-----------------|----------------|--------------|----------|---------|
| ARM (TO LEFT OF A) | 5985 (SHT 2:45) | - 88.2 | 19.75 | -527,877 | 118,203 |
| TAIL SECTION | | | | | |
| (TO RIGHT OF P.) | | | | | |
| 2 OUTSIDE I" AL | 815 | 27 | 29.1 | 22,005 | 23,716 |
| 2 INSIDE 1" A | . 600 | <i>35</i> . | 32. 3 | 21,000 | 19,380 |
| ВоПОМ 1" R | 420 | 67.5 | 29.6 | 28,350 | 12,432 |
| 1/2" 4 | 95 | 54 | <i>33.5</i> | 5130 | 3 /82 |
| VERTICAL PL'S | | | | | |
| | 51.0 | 93 | 36.5 | 4 743 | / 86/ |
| | 73.0 | 88 | 35.5 | 6 424 | 2 591 |
| • | 61.5 | 50 | 36.0 | 3 075 | 2214 |
| | 80.0 | 44 | 34.5 | 3 520 | 2 760 |
| • | 25.4 | 42 | 37.0 | 1 067 | 940 |
| | 55.0 | 36.5 | 39.5 | 2 008 | 1 898 |
| | 104.5 | 19 | 33.0 | 1 986 | 3 449 |
| • | 196.0 | 28 | 34.0 | 5 488 | 6 664 |
| | 210.0 | 10 | 3 <i>2.0</i> | 2 100 | 6 720 |
| | 44.0 | 56.5 | 27.5 | 2 486 | 1 210 |
| | 10.0 | 93.5 | 34.8 | 935 | 348 |
| | 144.0 | . 0 | 33.0 | 0 | 4 752 |
| DYWA- THERM | 158.0 | 28 | 32.0 | 4 424 | 5 056 |
| SKIN R 3/16" | 166.0 | 46.5 | 39.4 | 7719 | 6 540 |
| COUNTER WEIGHT * | 1 | 51.0 | 35.0 | 310,080 | 212,800 |

* SEE SHTS. .8-62

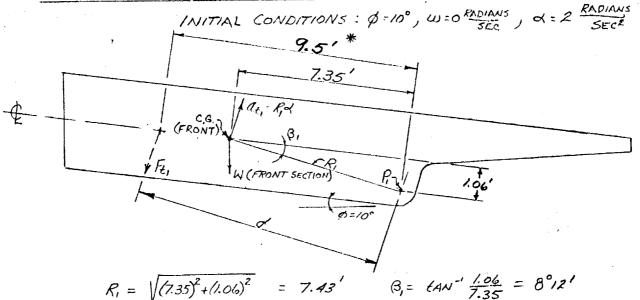
BY DATE SUBJECT CENTER OF GRAVITY
CHKD. BY DATE OF ARM, TAIL SERVICE MAST

| ITEM | WEIGHT (#) | X | V | WX | WV |
|--------------|--------------|-------|---------------|---------|---------|
| TAIL SECTION | | | | | |
| TOTAL | 9 388 | 46.07 | <i>33.9</i> 3 | 432,540 | 318,533 |
| ARM | · | , | | | |
| TOTAL | 15,373 | -6.2 | 28.45 | -95,347 | 437,360 |
| | | | | | |

$$R_2 = \sqrt{(46.07)^2 + (26.93)^2} = 53.4''$$

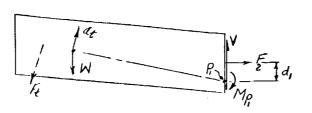
$$\theta = \tan^{-1} \frac{26.93}{46.07} = 30^{\circ}18'$$

TO DETERMINE INITIAL FORCE ON CYLINDERS



$$F_{t_1} = \frac{W}{9}R_1 d = \frac{5985}{32.2} \times 7.43 \times 2 = 2760^{\#} d = \sqrt{9.5^2 + 1.06^2} = 9.55'$$

CUT ARM AT PIVOT AND SUM MOMENTS ABOUT P



$$\sum M_{P_i} = \left(\frac{\omega}{g} R_i \propto\right) d + \omega R_i C_0 S(\phi + \theta_i) - F_i d_i$$

$$Mp_1 = 2760 \times 9.55 + 5985 \times 7.43 \times \cos 18^{\circ} 12^{\prime} - \mathcal{E}_{i}$$

$$Mp_2 = 68,600 \quad F_{i} - \# - \mathcal{E}_{i}$$

NOW SUM MOMENTS TO RIGHT OF P, & SET EQUAL TO MP, + MP

FRICTION MOMENT (Mp)

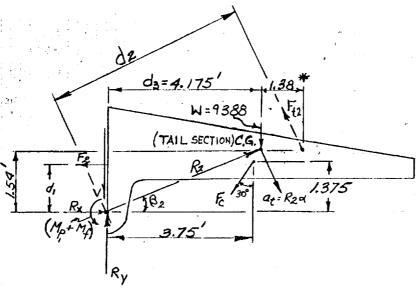
Mp = WHA = 15,373 x 0.15 x 2/12 = 384 FT-# (FRICTION MOMENT @ PIVOT)

W = DEAD WEIGHT OF ARM = 15,373# M = COEFFICIENT OF FRICTION = 0.15 Q = RADIUS OF PIVOT PIN = 2"

8-68

CHKD. BY_____DATE____

TAIL SERVICE MAST



 $F_{C} = CYLINDER LOAD REQUIRED TO OBTAIN INITIAL <math>d \left(\frac{RAd}{SEC.2} \right)$ $R_{2} = 53.4''$ $G_{2} = (3-10') = 30'/8'-10' = 20'/8', d_{3} = R_{2} \cos \theta_{2}$ (4.45') $G_{2} = MR_{2} \propto \frac{9388}{32.2} \times 4.45 \times 2 = 2595^{\#}$ $d_{2} = \sqrt{1.54^{2} + 5.555^{2}} = 5.76$

IM = Mp + Mf =- Fd2 - Ed, - 1.375 E SIN30° + 3.75 FC COS30°+ Wd3

68,600-74 + 384 = -2595 x 5.76 -74-.687Fc + 3.25Fc + 4.175 x 9388
2.563 Fc = 62,750 + 384 + 14,950 - 39,200

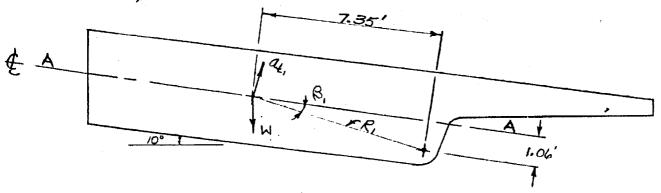
 $F_{c} = \frac{38,884}{2.563} = \frac{15,150}{100} + \frac{(CYLINDER LOAD REQ'D FOR INITIAL ARM ACCELERATION OF 2 RADIANS/SEC²)$

* THE TWO DIMENSIONS 9.5' & 1.88' ARE CLOSE APPROXIMATIONS.

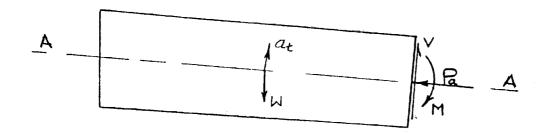
THE 9.5' DIMENSION BASED ON THE MAX. MOMENT AT PIVOT. THE 1.38 DIMENSION BASED ON THE MAX. MOMENT AT SECTION B-B. (SEE SHT. 8-75)

| 9YDATE | SUBJECT MAMINAM AMAL LOAD IN | SHEET NOOF |
|---------------|-------------------------------|------------|
| CHKD. BY DATE | FRONT SECTION UNDER DYNAMIC | JOB NO |
| | CONDITIONS. TAIL SERVICE MAST | |

THE ANGULAR VELOCITY ω : 0: THE NORMAL ACCELERATION (α_N) $\alpha_N = \gamma'\omega^2 = 0$. THE NORMAL ACCELERATION FORCE = 0.



 $W = 5985^{\#}$ $E_1 = 7.43'$ (SEE SHT. 8-68) $a_{t_1} = R. \Delta$ $F_{t_1} = ma_{t_1} = \frac{5985}{52.2} \times 7.43 \times 2 = 2760^{\#}$ $\Theta = 8^{\circ}12'$



Ra = NSIN10' - Ft, SIN 8'12'
Ra = 1040 - 393 = 647#

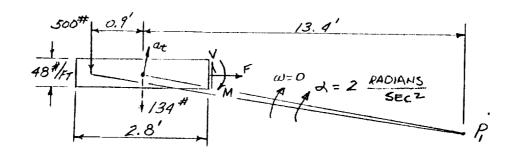
| BYDATE | SUBJECT SHEAR IN ARM @ INITIAL ACCELERATION | SHEET NOOF |
|--------|---|------------|
| | TAIL SERVICE MAST | JOB NO |

SHEAR CALCULATIONS

INITIAL CONDITIONS: \$=10° W=0 &=2 BOOMS
SEE SHT. B-64 FOR "g" VALUES.

1. SHEAR AT UMBILICAL GROUND HALF TO LEFT OF PIVOT P.

2. SHEAR AT END OF ARM TO LEFT OF PIVOT P.



3, SHEAR 9.125' TO LEFT OF PIVOT.

4. SHEAR 1.46 TO LEFT OF PIVOT.

- 5. SHEAR TO PIVOT (P) V = 7950 + 500 x 1.96 x 1.03 = 8700#
- 6. SHEAR 3.45' TO RIGHT OF PIVOT

$$V = 53 \times .5 + \frac{1021 + 880}{2} \times .41 \times .52 + \frac{1922 + 752}{2} \times 3.26 \times .617$$
$$+ \frac{860 + 765}{2} \times .63 \times .753 + 200 \times .772 + F. \cos 20^{\circ}$$

$$Y = 26.5 + 203 + 2690 + 386 + 154.5 + 15,150 \times .94$$

 $V = 17,710^{\#}$

7. SHEAR 1.58' TO RIGHT OF P

$$V = 17,710 + \frac{860 + 955}{2} \times 0.81 \times .57 + \frac{2350 + 1867}{2} \times 1.3 \times .849$$

$$V = 17,710 + 419 + 2325 = 20,454$$

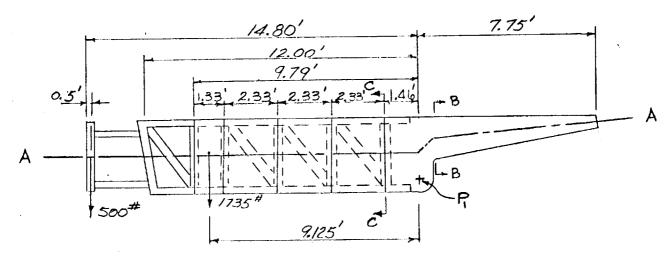
8. SHEAR AT PIVOT (R)

$$V = 20,459 + \frac{500 + 370}{2} \times .87 \times .915 + 500 \times .71 \times .963$$

 $V = 20,454 + 346 + 342$
 $V = 21,140^{\#}$

| BYDATE | SUBJECT MOMENT IN ARM (Q) | SHEET NO OF |
|--------------|---------------------------|---------------------------------------|
| CUVD BY DATE | INITIAL ACELERATION | JOB NO |
| | TAIL SERVICE MAST | # # # # # # # # # # # # # # # # # # # |

MOMENT CALCULATIONS INITIAL POSITION



SUM MOMENTS ALONG ARM ABOUT A-A
FOR LOADS & "g's" SEE SHEET 8-69

1. MOMENT 12' TO LEFT OF PIVOT.

 $M = 500 \times 1.87 \times 2.3 + 48 \times \frac{2.8}{2} \times 1.81$ M = 2150 + 340 = 2490 FT- #

2. MOMENT 9.79' TO LEFT OF PIVOT.

 $M = 500 \times 1.87 \times 4.51 + 48 \times 2.8 \times 3.61 \times 1.81 + 210 \times \frac{2.21}{2} \times 1.66$ M = 4200 + 878 + 852 = 5930 FT- #

3. MOMENT 1.46 TO LEFT OF PIVOT. (SECTION C-C)

 $M = 500 \times 1.87 \times 12.84 + 48 \times 2.8 \times 1.81 \times 11.94 + 210 \times 2.21 \times 1.66 \times 9.435 + (1735 + 290 \times 1.33) \times 1.55 \times 7.665 + 290 \times 2.33 \times 1.435 \times 5.835 + 290 \times 2.33 \times 1.291 \times 3.50 + 290 \times 2.33 \times 1.147 \times 1.165$

M = 12,000 +2900 +7275 + 25,150 + 5650 + 3055 + 903 M = 56,933 FT-#

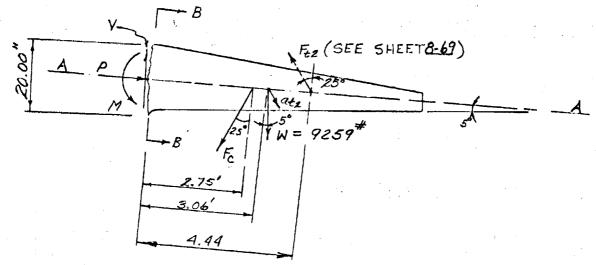
| YDATE | SUBJECT MOMENT CALCULATIONS (SOUT) | SHEET NO OF |
|---------------|------------------------------------|-------------|
| CHKD. BY DATE | TAIL SERVICE MAST | JOB NO |

MOMENT CALCULATIONS (CONT.)

4. MOMENT ABOVE PIVOT "P" ABOUT A-A.

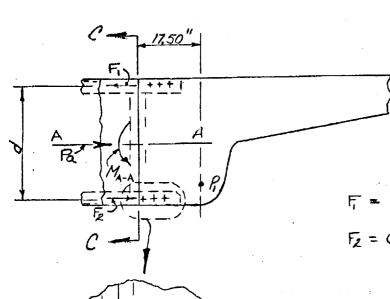
 $M = 500 \times 1.87 \times 14.3 + 48 \times 2.8 \times 1.81 \times 13.4 + 210 \times 2.21 \times 1.66 \times 10.895$ $+ (1735 + 290 \times 1.33) \times 1.55 \times 9.125 + 290 \times 2.33 \times 1.435 \times 7.295$ $+ 290 \times 2.33 \times 1.29 \times 4.955 + 290 \times 2.33 \times 1.147 \times 2.625 + 500 \times \frac{1.46^{2}}{2} \times 1.03$ M = 13,380 + 3255 + 8380 + 30,000 + 7075 + 4320 + 2030 + 550 M = 68,790 FT-#

5. MOMENT AT SECTION B-B ABOUT A-A.



 $M = Fc \cos 25^{\circ} \times 2.75 + W \cos 5^{\circ} \times 3.06 - F_{2} \cos 26^{\circ} \times 4.44$ $M = 15,150 \times 0.906 \times 2.75 + 9259 \times .976 \times 3.06 - 2500 \times .899 \times 4.44$ M = 56,000 FT - #

| BYDATE | BUBLECT SHEAR PINGRAMS FO ACCELERATION | R THITINI | <u> </u> | SHEET NOOF |
|--|--|----------------------------|----------------|---------------------------------------|
| CHKD. BY DATE | ACCECERATION | 1. TAIL SET | PUICE MAKT | JOB NO |
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| FRONT OF A ARM 1177# 4995# | 5/38# 6075* | | | |
| /// +145*** | | | | |
| | 70 | 7950# | 8700# | |
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| | | | 56.00 | O (SECTION B- |
| | (SECTION C-C) | 56,933 | , / | (|
| | | \ | ! / | |
| | | | :/ | |
| | | | Y 68, 990 / | FT-# (ABOVE PI |
| | | | | · · · · · · · · · · · · · · · · · · · |
| | | | | |



MA-A @ SECTION C-C MA-A = 56, 933 FT-# (SEE SHT. 8-75) d = 39.5 - 2(2.5) = 34.5 IN. $T = C = \frac{M}{d} = \frac{56,933}{2.34.5} \times 12 = 9900^{\#}$

F = T-Pa = 9738 # Pa=647 (SEE SHT. 8-20) $F_2 = C + \frac{P_2}{4} = 10,062^{\#}$

3-8" DIA. UNBRAKO BOLTS *

V (ALLOWABLE IN SINGLE SHEAR) = 57,700

V (ALLOWARLE) = 57,700# = 19,250#

V(ACTUAL) = 10,062 = 3350#

* REF: "LINBRAKO SOCKET SCREW CATALOG AND ENGINEERING STANDARDS,"
PAGE 48-49, STANDARD PRESSED STEEL CO., JENKINTOWN, PA.

AREA = 1/2 x 7/8 = 0.44 " PER BOLT BEARING:

ALLOWABLE BEARING STRESS = 1.35 Fy = 1.35 x 36 = 48 KSi

LOAD PER BOLT = 48x.44 = 21 KSI/BOLT TOTAL ALLOWABLE LOAD = 21x3 = 63 KSI O.K.

L4x4x 12 , AREA = 3.75 4" COMPRESSION:

MAX. COMPRESSION LOAD PER ANGLE = 3.75x12 = 45 K

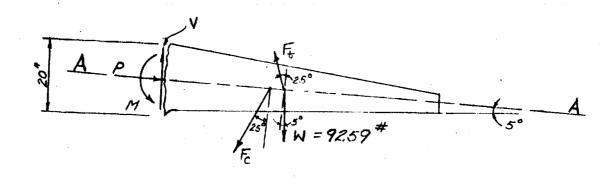
MIN. SHEAR PER BOLT = 57.7 K

ALLOWABLE = 57.7x(NO. BOLTS) NO. BOLTS = 3 5. F. = 3

ALLOWABLE = 57.7 × 45 K

SHEET NO..... OF.....

INITIAL CONDITIONIS: $\phi = 10^{\circ}$, $\omega = 0$ RADIANS $\omega = 2$ RADIANS



M = 56,000 FT.-# (SEE SHEET 8-75.)

P = ESIN25° - WSIN5° + FSIN25°

P= 15,150 x.423-9259 x 0.087 + 2500 x 0.423 = 6672#

CONSIDER TWO OUTSIDE I" PLATES TAKE ENTIRE LOAD.

A = 2 x 20 = 40 M2

V = Fc COS 25° + WCOS 5° - F. COS 25°

V = 15,150x.906 + 9259x0.996 - 2500x0.906 = 20,678 #

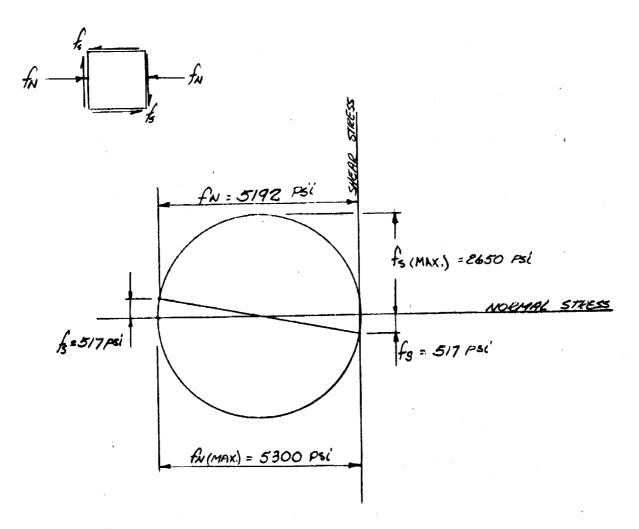
COMBINED NORMAL STRESSES:

 $f_N = \frac{6672 + 56,000 \times 12 \times 10}{40} = 5192 \text{ or } 4859 \text{ Poi}$

SHEAR STRESS:

$$f_s = \frac{V}{A} = \frac{20,678}{40} = 517 \text{ psi}$$

| | SUBJECT STRESS CALCULATIONS | SHEET NO OF |
|----------|-----------------------------|-------------|
| BYDATE | (CONT.) | _ JOB NO |
| CHRU. BI | | |



factual) = 5300 psi

factual) = 5300 psi

fall. = 36,000 = 12,000 psi

OK

AT FRONT OF ARM DUE TO LIMBILICAL ATTACHMENT

SHEET 8-75

FT-# (SEE

2490

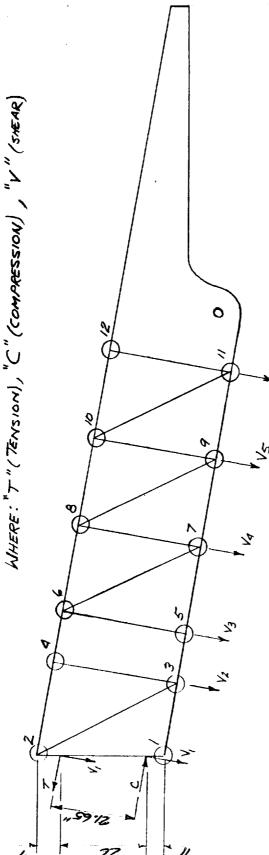
%

MOMENT

069 =

T=C=2490x12

OF ARM WITH INCLUDED.



SHORE REPRESENT TOTAL PANEL POINTS. THESE VALUES OF SHEAR AT THEIR RESPECTIVE

SHEET B-75 (SEE

3040#

11

6075

74

11

562 =

= 1050

= 3500#

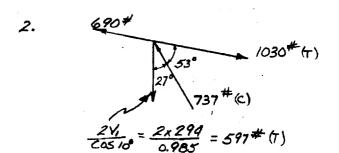
・シシ

IS SMALL COMPARED LOAD WILL ONLY BE AXIAL LOADING THE JOINTS SHEAR 工工 THE THE SINCE ADDED

SHEET NO..... OF....

TAIL SERVICE MAST

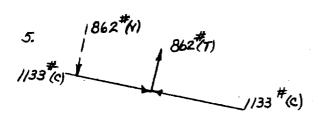
1.

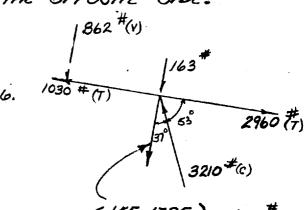


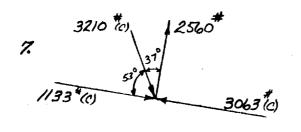
3.

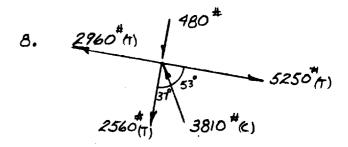
NOTE: THE TWO MEMBERS 3-5 \$ 4-6 WILL BE REQUIRED TO TRANSMITT VERTICAL SHEAR DOWN THE ARM. IT WILL BE ASSUMED THAT EACH MEMBER WILL CARRY AN EQUAL AMOUNT OF VERTICAL SHEAR.

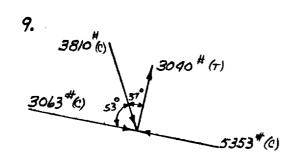
THE LOAD DUE TO THE HOOD IS TAKEN BY MEMBERS 3-4,5-6 F THEIR CORRESPONDING MEMBERS ON THE OPPOSITE SIDE.

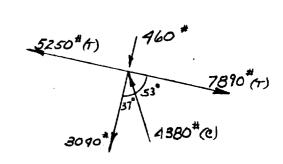


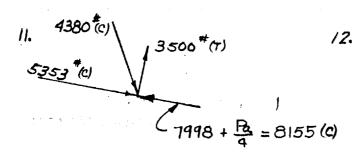


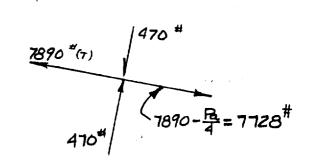












Pa = 647 (SEE SHT. 8-70)

SUBJECT CENTER OF GRAVITY OF BASE , TAIL SERVICE MAST

SHEET NO......OF.......

CENTER OF GRAVITY OF BASE

| ITEM | SIZE | VOLUME (IN.3) | X | Ē | VZ | <i>∨₹</i> |
|---------------------|---------------|------------------|--------|-------|---------|-----------|
| 2 FRONT ANGLES | 2x3.75x83 | 622.5 | -18.75 | 41.0 | -12,300 | 25,000 |
| 4 BACK ANGLES | 4x3.75x88.4 | 1326.0 | 28.0 | 41.0 | 37,128 | 54,366 |
| VERTICAL STIFFENERS | 8x 3/4x8x2 | . 96.0 | -17.0 | 41.0 | -697 | 3936 |
| 4 SIDE | 4×10×3/4×83 | 12490.0 | - 1.5 | 41.0 | - 3735 | 102,090 |
| 2 SIDE | 2×10×3/4×40.9 | 606.0 | 26 | 20.47 | 15,756 | 12,405 |
| HORIZ. STIFFENERS | | | | | | |
| •• | 4x 4/4 x 19 | 57 | -22 | 12,5 | -1254 | 7/3 |
| | 10×15.5×2×1 | 302 | -19 | 12.5 | -5738 | 3 775 |
| | 35×10×1 | 350 | 6.5 | 12.5 | 2275 | 4375 |
| | 112921 | 99 | 33 | 12.5 | 3267 | 1237 |
| | 3.75x 32x1 | 120 | 39 | 9.0 | 4680 | 1080 |
| | 2×10×17.5×1 | <i>3</i> 50 | -18 | 24.5 | - 6300 | 8575 |
| | 4x18.75x1 | 75 | -21 | 24,5 | - 1575 | 1838 |
| | 2×35×10×1 | 700 | 6.5 | 24.5 | 4550 | 17,150 |
| | 2×11×9×1 | 198 | 32 | 24.5 | 6336 | 4 752 |
| | 2x 9x/6x/ | 288 | -16 | 42.5 | -4608 | 12,240 |
| | 2x/0x38x/ | 760 | 5 | 42,5 | 3800 | 32,300 |
| | 2x6,5x15x1 | 195 | -15.5 | 55,25 | -3022 | 10,773 |
| | 4x20x1 | 80 | -1.5 | 55.25 | - 120 | 4420 |
| ÷ | 8.5x20x1 | 170 | -1.5 | 55,25 | - 255 | 9393 |
| | 2x9x14x1 | 252 | 16.5 | 55,25 | 4/58 | 13,923 |
| | 4x12x10x1 | 480 | 0 | 80 | 0 | 38,400 |
| | 3.75×31×/ | 116.25 | 17 | 73 | 1977 | 8 186 |
| | 2x8x10x1 | 160. | 0 | 80 | 0 | 12,800 |
| | 9.5×11.5×2×1 | 218.5 | -5,5 | 74.5 | -1201 | 16,279 |

| ITEM | SIZE | VOLUME | R | <i>₹</i> | VF | VZ |
|----------------------|------------|--------|-------|----------|---------|---------|
| HORZ. STIFFENERS | | | | | | |
| (COUT.) | 8x9.5x2x1 | 152 | 4 | 74.5 | 608 | 11,324 |
| | 7x/3x2x1 | 1,82 | -14.5 | 74.5 | -2639 | 13,559 |
| | 4x18x1 | 72 | -15.0 | 74.5 | - 1080 | 5364 |
| Top The | 2x12x30.75 | 738 | - 2 | 83.0 | - 1476 | 61,254 |
| | 15x 22.5x1 | 337.5 | 7 | 83.0 | 2360 | 27,681 |
| Top Lugs | | 2094 | 0 | 88.8 | 0 | 185,947 |
| BOTTOM R | | 2475 | 9.5 | .375 | 23,513 | 928 |
| SIDE SKIN A | 3/8" THICK | 3237 | 4.65 | 35.5 | 15,000 | 93,700 |
| FRONT SKIN K | 3/8" THICK | 1618 | -22.0 | 39.0 | -35,600 | 63,000 |
| BACK SKIN A | 3/8" THICK | 917 | 31.0 | 37,2 | 28,400 | 34,100 |
| MASTER ACTUATOR UNIT | | 8100 | | | | |
| TOTAL | | | | | | |

WEIGHT BASE STRUCTURE =
$$\frac{488 \times 21,934}{1728} = 6200 \#$$
 \overline{X} (STRUCTURE) = $\frac{72,210}{21,934} = 3.3"$

$$\overline{Z}$$
 (STRUCTURE) = $\frac{897,167}{21,934} = 41''$

WEIGHT LINES, CYLINDERS, FER. = 1300#

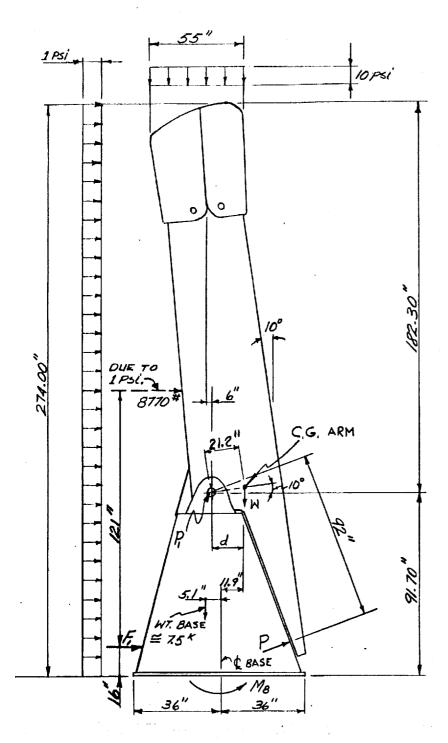
X = 7.5" (ASSUMED)

Z = 46" (ASSUMED)

TOTAL WEIGHT OF BASE = 6200 + 1300 = 7500 #

$$X = \frac{7.5 \times 1300 + 6200 \times 3.3}{7500} = 4''$$

$$\overline{Z} = \frac{46 \times 1300 + 41 \times 6200}{7500} = 42''$$



F (DECK WASH) = 110 K REF: MEMORANDUM TO MR. TRAVIS, LO-DE22 FROM CHIEF, PROPULSION AND MECHANICS BRANCH, M, PEVE-P. (ITEM 4) DATE: SEPT. 11, 1963

PROJECTED AREA OF HOOD

A = 55x33 = 1815 1N,2

E = RxA = 1815x10 = 18150

FOR C.G. & WEIGHT OF ARM (SEE SHT. 8-66) WE 15. 3 K d = 21.2 cos 10° = 20.9"

TO HORIZONTAL PRESSURE OF 1 PSC.

LOAD = 274 x 32 x 1 = 8770# \[\int M_{P} = 0 \]
\[18150 x 6 + 92 P = 15,300 x 20.9 \]
\[+ \left(\frac{82.3}{3} x 32 x 1 \]

 $P = \frac{320,000 + 534,000 - 109,000}{92}$ P = 8100 #

REACTIONS ON PIVOT:

 $\Sigma F_{\nu} @ F_{\nu} \sigma \tau = 0$ $R_{\nu} = 18150 + 15300 - 51N20^{\circ} 8100 = 30,680^{\#}$ $\Sigma F_{\mu} @ P_{\nu} \sigma \tau = 0$ $R_{\mu} = 182.3 \times 32 \times 1 + Cos 20^{\circ} \times 8100 = 5840 + 7620 = 13,460^{\#}$ $R = \sqrt{(R_{\nu})^{2} + (R_{\mu})^{2}} = \sqrt{(30.68)^{2} + (13.46)^{2}} = 33,600^{\#}$

OVERTURNING MOMENT "M" AND VERTICAL LOAD ABOUT THE CENTERLINE OF BASE WITH LOAD OF 1 PSI ACTING HORIZONTAL TO THIL SERVICE MAST.

\(\mathbb{M}_{\psi} BASE = 0

 $M_{B} = 15,300 \times 11.9 + 8770 \times 137 - 5.1 \times 7500$ $M_{B} = 182,000 + 1,200,000 - 38,200$ $M_{B} = 1,343,800 \text{ M-H} = 112,200 \text{ FT-H}$

TOTAL VERTICAL LOAD ACTING ON BASE,

 $F_V = 15,300 + 7500 = 22,800$ TOTAL HORIZONTAL LOAD, $F_H = 8770 \#$

OVERTURNING MOMENT Mg" AND VERTICAL LOAD
ABOUT THE CENTERLINE OF BASE WITH LOADS OF
10 PSI VERTICAL AND 1 PSI HORIZONTAL ACTING ON
TAIL SERVICE MAST PUS 110 " DUE TO DECK WASH.

\(\mathbb{M}_{\mathbb{E} \backsigma} = 0 \)

 $M_B = 15,300 \times 11.9 + 8770 \times 137 - 5.1 \times 7500 - 18,150 \times 15 + 110,000 \times 16$ $M_B = 182,000 + 1,200,000 - 38,200 - 272,000 + 1,760,000$ $M_B = 2,831,800$ IN-# = 236,000 FT-#

TOTAL VERTICAL LOAD ACTING ON BASE

Fv = 15,300 + 7500 + 18,150 = 40,950#

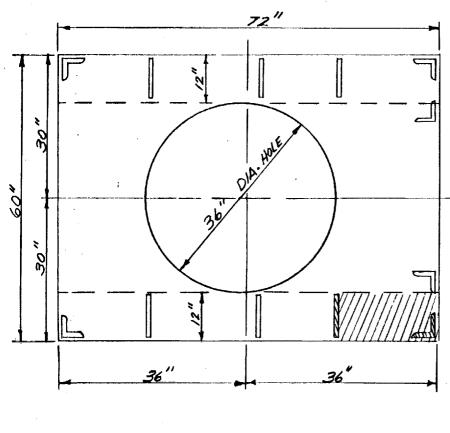
TOTAL HORIZONTAL LOAD ACTING ON BASE

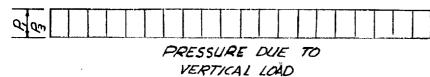
FH = 110,000 #

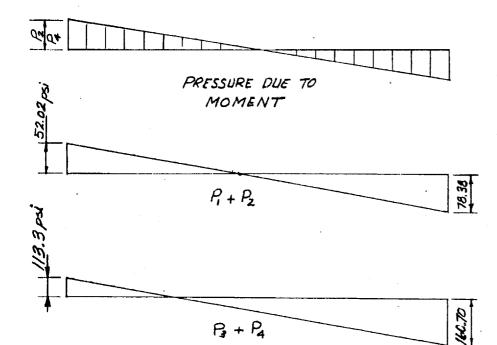
SHEET NO..... OF....

| BYDATE | BUBLECT BASE A CALCULATIONS UNDER | SHEET NOOF |
|--------|-----------------------------------|------------|
| | FIRING COMPITIONS | JOB NO |
| | TAIL SERVICE MAST | |

BASE PLATE CALCULATIONS







OMIT AREA INSIDE OF DASHED LINES FOR CALCULATION PURPOSES

BEARING AREA A = 2x12x72 A = 1730 14,2

ASSUME VERTICAL LOADS TO BE UNIFORMLY DISTRIBUTED ON BASE

PRESSURES: $P_1 = \frac{22,800}{1730} = 13.18 \text{ Psl.}$

I= 1/12 x 2x 12 x 723 I= 746,000 IN.4

M2 = 1,343,800 IN-#

M4=2,831,800 W-#

 $S = \frac{T}{c} = \frac{746,000}{36}$ $S = 20,700 \text{ IN.}^3$

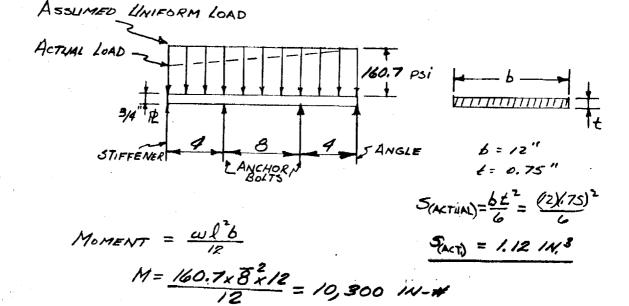
P2 = 1,343,800 = 65.2 psi.

 $P_3 = \frac{40,950}{1730} = 23.7 \text{ psi}$

P4 = 2,831,800 = 137 psi

| BYDATE | BUBLECT BASE R CALCULATIONS (COM) | SHEET NO OF |
|--------------|-----------------------------------|-------------|
| CHKD. BYDATE | *** | JOB NO |
| | TAIL SERVICE MAST | |

BASE PLATE CALCULATIONS (CONT.)



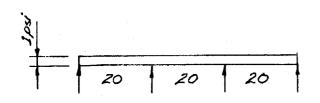
$$S(REQUIRED) = \frac{M}{fall}$$
. A-36 STEEL
$$f(allowable) = \frac{36,000}{3} = 12,000 psi$$

$$S(REQ'D) = \frac{10,300}{12,000} = 0.86 M^{3}$$

S(REG'D) < S(ACT) : O.K.

SKIN PLATE

ASSLIME $\frac{3}{8}''$ $\frac{1}{12}$, ASTM A-36 STEEL f(ALLOWABLE) = 12 KSi $S = \frac{bd^2}{6} = \frac{1 \times \frac{3}{8} \times \frac{3}{8}}{6} = .0234$



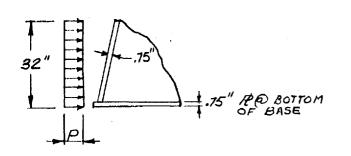
$$M = \frac{\omega l^2}{8} = \frac{1 \times \overline{20}}{8} = 50" \#$$

$$f(ACTUAL) = \frac{M}{3} = \frac{50}{.0234} = 2140 psi OK$$

BOTTOM SKIN & @ FRONT:

ASSUME 110 * FORCE DUE TO DECK WASH IS DISTRIBUTED

AS SHOWN BELOW.



$$P = \frac{110,000}{32\times60} = 57.3 \text{ psi}$$

MAX OPENING BETWEEN STIFFENERS IN THIS AREA IS 18" SPAN. USE MOMENT COEFFICIENT OF .033 FROM TABLE 3, SECTION 709, ACI BUILDING CODE (ACI 318-56)

C = .033 (MOMENT COEFFICIENT)

(MOMENT)
$$M = C \times P \times (SPAN)^2$$

 $M = .033 \times 57.3 \times \overline{18}^2 = 613 "#$
 $S(REQ'D) = \frac{M}{f} = \frac{613}{12,000} = .052 /4.3$

$$S(3/4''/k) = \frac{bd^2}{b} = \frac{1 \times .75}{6} = .094 \text{ IM.}^3 :.OK$$

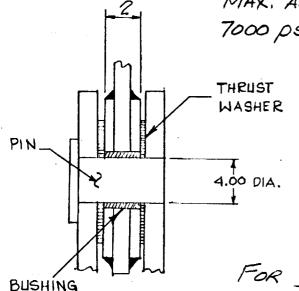
PIVOT (MAXIMUM VALUES)

TOTAL REACTION @ PIVOT = 33,6 K (SEE SHT.) REACTION @ EACH PIN = 33.6 = 16.8 K

BUSHING: USE LUBRITE BRONZE, ALLOY 423 - SELF LUBRICATING, BY LUBRITE DIVISION, MERRIMAN BROS., INC., BOSTON 30, MASS.

> DESIGN REFERENCE : "LUBRITE MANUAL NO. 56"

AS MAX, LOADING OCCURS IN A STATIC CONDITION, CLASS OF SERVICE WILL BE CONSERVATIVELY TAKEN AS INTERMITTENT TYPE OF DUTY AS HEAVY. THIS GIVES A MAX, ALLOWABLE BEARING PRESSURE OF 7000 psc.



BEARING AREA = 4×2 = 8 SQ. IN.

ACTUAL BEARING PRESSURE = 16.8 = 2.1 KSI

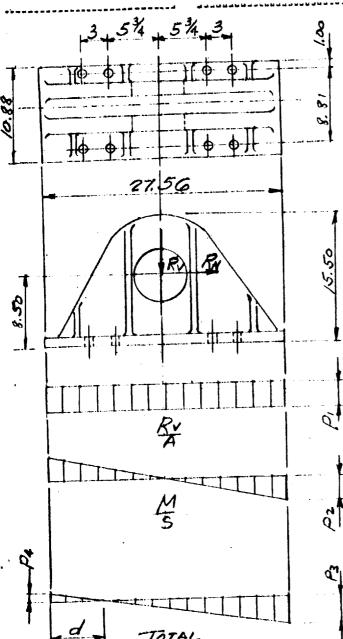
MIN. THICKNESS = INSIDE DIA + 1/8 (RECOMMENDED)

USE THICKNESS = 4 + 1 = 3/8 INCH

FOR THRUST WASHER, USE 1/4 INCH THICK BY 10 INCH OUTSIDE DIAMETER.

Pin: AREA PIN = $\frac{\text{TD}^2}{1} = 3.14 \times 4 = 12.55 \text{ IN.}^2$

SHEAR STRESS = 16,800 = 670 PSI. O.K.



HORIZONTAL SHEAR IS O.K. BY INSPECTION.

$$P_{1} = \frac{RV}{A} = \frac{15,320}{10.88 \times 27.56} = \frac{51.2 \text{ psi}}{(\text{MAX})}$$

$$P_{1} = \frac{6780}{10.88 \times 27.56} = 22.6 \text{ psi} (\text{MIN})$$

$$P_{2} = \frac{15}{10.88 \times 27.56} = 22.6 \text{ psi} (\text{MIN})$$

$$P_{3} = \frac{57,700}{137.5} = 42 \text{ psi}$$

$$P_{4} = \frac{57,700}{137.5} = 42 \text{ psi}$$

$$P_{5} = \frac{51.2 + 42}{137.5} = 42 \text{ psi}$$

$$P_{7} = \frac{51.2 + 42}{137.5} = 42 \text{ (MAX)}$$

$$P_{7} = \frac{51.2 + 42}{12.6 + 42} = 64.6 \text{ (MIN)}$$

$$P_{7} = \frac{19.4}{19.4 + 64.6} = \frac{19.4 \text{ (MAX)}}{19.4 + 64.6}$$

$$P_{7} = \frac{19.4}{19.4 + 64.6} = \frac{19.4 \times 6.36}{19.4 + 64.6} = \frac{19.4 \times 6.36}$$

ASSUME 8-3/4 DIA. BOLTS

(MS 35303, Y.S. = 150,000)

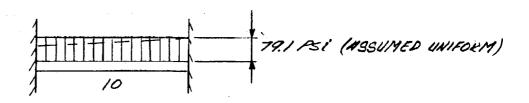
USE SAFETY FACTOR OF 3
ALLOWABLE STRESS = 150,000

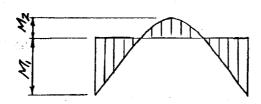
SHEAR STRESS = $f_v = \frac{6780}{8 \times .302} = 2800 psi$ (AREA 3/4 BOLT = .302)

ALLOWABLE TENSION STRESS = $F_t = 50,000 - 1.6 f_v \le 40,000$ $F_t = 50,000 - 1.6 \times 2800 = 45,000,000$ 8-90

| BYDATE | SUBJECT BASE CAP PLATE | SHEET NO OF |
|---------------|------------------------|-------------|
| CHKD. BY DATE | | JOB NO |
| | TAIL SERVICE MAST | |

CAD PLATE





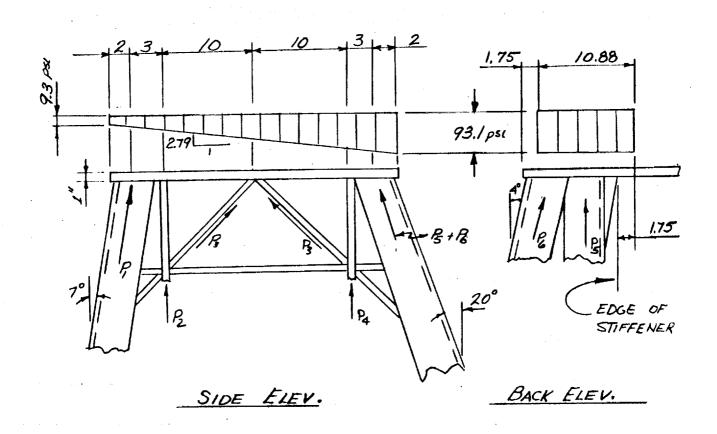
$$M_{1} = \frac{\omega l^{2}}{12} = \frac{79.1 \times 70^{2}}{12} = 659^{11} \#$$

$$M_{2} = \frac{\omega l^{2}}{24} = \frac{79.1 \times 10^{2}}{24} = 329.5^{11} \#$$

$$S(REQ'D) = M$$
 $f(ALLOWABLE)$
 $f(ALLOWABLE) = 12 \text{ KS}i$
 $S(REQ'D) = \frac{659}{12000} = 0.0549$
 $S(I'R) = \frac{117^2}{6} = 0.167 \text{ OK}$
 $f(ACTUAL) = \frac{659}{0.167} = 3945 \text{ ps}i$

| BYDATE | SUBJECT BASE CALCULATIONS | SHEET NOOF |
|-------------------------|---------------------------|------------|
| | | JOB NO |
| AUUN. Gisses-puigionis- | TAIL SERVICE MAST | |

SEE SHT___ FOR LOADS .



 $P_{i} = [10.88 \times 9.3 \times (2+1.5) + 1/2 \times 2.79 \times 3.5^{2} \times 10.88] / \cos 7^{\circ} = 543^{\#}$ $P_{i} = (9.3 + 2.79 \times 3.5) / (1.5 + 5) / 10.88 + 1/2 \times 2.79 \times 6.5^{2} \times 10.88 = 2089^{\#}$ $P_{i} = \frac{1}{2} [(9.3 + 10.00 \times 2.79) / 10.88^{2} + 1/2 (2.79) / 10.00^{3}] / 5445^{\circ} = 4100^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.77 \times 20) / (5 + 1.5) / 10.88 + 1/2 \times 2.79 \times 6.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88] / \cos 20^{\circ} = 3570^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88] / \cos 20^{\circ} = 3570^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88] / \cos 20^{\circ} = 3570^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2) / 10.88 + 1/2 \times 2.79 \times 3.5^{2} \times 10.88 = 5215^{\#}$ $P_{i} = \frac{1}{2} (9.3 + 2.79 \times 26.5) / (1.5 + 2$

VERTICAL STIFFENERS IN BASE

ASSUME 34" R'S (10" WIDE)

A= 10x 34 = 7.5 #"

$$r = \frac{d}{7/2} = \frac{34}{V/2} = 0.217$$

SINCE STRUCTURE WILL BE SUBJECTED TO VIBRATIONS, LIMIT S/L TO 120.

REFERENCE AISC SPECIFICATIONS FOR
A-36 STEEL (SAFETY FACTOR = 1.65)

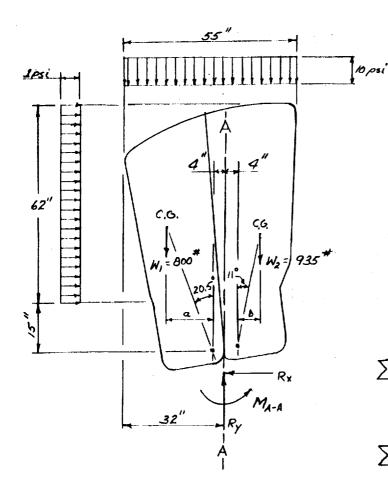
(SINCE A SAFETY FACTOR OF 3 IS DESIRED OVER 1.65 BY AISC.)

THEN - $f(ACTUAL) = \frac{P}{A} = \frac{5215}{7.5} = 695 psi$

CORNER MEMBERS

ASSUME $1.4 \times 4 \times 2$ A = 3.75 % , $\Gamma = 0.78$ $1(MAX) = 0.78 \times 120 = 93.5\%$

f(ACTUAL) = PA = 1785 = 476 PSI



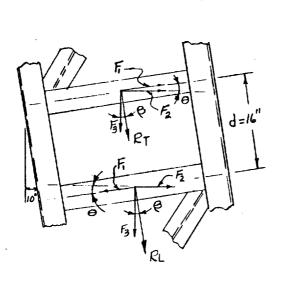
ASSUME HOOD SINGLE UNIT AND THAT REACTIONS ACT AT A POINT,

WIDTH OF HOOD = 33"

 $a = 40.8 \times 0.35 = 14.3$ " $b = 36.9 \times 0.191 = 7.1$ " TO SUM MOMENTS ABOUT A-A $ADD A''' TO DIMENSIONS <math>a \notin b$ $a + 4 = 18.3 \notin b + 4 = 11.1$ $\sum F_y = 10 \times 55 \times 33 + 800 + 935 = R_y$ $R_y = 19,885$ $R_y = 62 \times 33 \times 1 = 2046 = R_y$

 $\sum_{A-A} M_{A-A} = 935 \times 11.1 + 62 \times 33 \times 1 \times 46 - 800 \times 18.3 - 55 \times 10 \times 33 \times 4.5$ $M_{A-A} = 10,400 + 94,000 - 19,600 - 81,700 = 8100 IN-4$

REACTIONS ON ARM CREATED BY ABOVE LOADS.



$$F_{1} = \frac{M}{2d} = \frac{8100}{2 \times 16} = 253^{\#}$$

$$F_{3} = \frac{Ry}{4} = \frac{19,885}{4} \approx 5000^{\#}$$

$$F_{2} = \frac{Rx}{4} = \frac{2096}{4} \approx 520^{\#}$$

| BYDATE | BUBJECT HOOD LOAD | SHEET NO OF |
|--------------|-------------------|-------------|
| CHKD. BYDATE | | JOB NO |

RESULTANT RT TOP MEMBER (SEE SKETCH, SHT. 8-94)

$$R_{\tau}^{=} \sqrt{(f_3 - f_5)^2 + (f_2 + f_5 \cos^2)^2}$$

$$R_{7} = \sqrt{(5000 - 44)^{2} + (520 + 249)^{2}}$$

$$R_{7} \leq 5015 \stackrel{\#}{=} \leq 5^{K}$$

$$B = tan^{-1} \frac{F_2 + F_1 \cos \theta}{F_3 - F_1 \sin \theta}$$

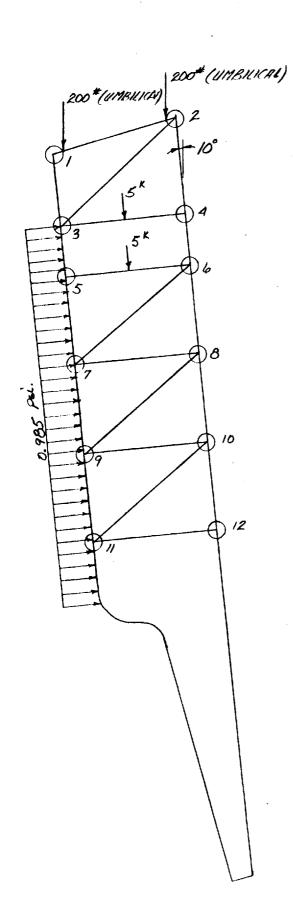
RESULTANT RL LOWER MEMBER

$$R_{L} = \sqrt{(F_{3} + F_{1} \leq N \theta)^{2} + (F_{2} - F_{1} cos \theta)^{2}}$$

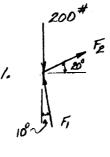
$$R_{L} = \sqrt{(5044)^{2} + (27/)^{2}}$$

$$R_{L} = 6046^{\frac{4}{3}} \approx 5^{\frac{1}{3}}$$

ALSO ASSUME RL ACTS 1

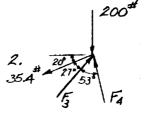


AT EACH PANEL THE WEIGHT OF THE ABOVE SECTION WILL BE INCLUDED. (FOR WEIGHTS SEE SHT. 8-64.)



 $200 - F_{1} \cos 10^{\circ} - F_{2} \sin 20^{\circ} = 0$ $F_{2} \cos 20^{\circ} - F_{1} \sin 10^{\circ} = 0$ $F_{3} = \frac{F_{1} \sin 10^{\circ}}{\cos 20^{\circ}} = 0.185 F_{1}$ $200 - 0.985 F_{1} - 0.342 \times 0.185 F_{1} = 0$

Fi = 191 # (C) Fz = 0.185 Fi = 35, 9 *(T)



200 +35,45IN20°-F, COS43°-F4 COSIO° = 0 35,4 COS 20° + F4 SINIO° = F, SIN 43°

$$F_3 = \frac{./736 \, F_4 + .94 \times 35.4}{.682}$$

200 + 35.4x .342 - .731 (0.174 F4 + .94x 35.4)

$$F_4 = \frac{200 + 12.1 - 35.8}{1.127} = \frac{176.3}{1.127}$$

$$F_{\xi} = \frac{./736 \times ./56 + .94 \times 35.4}{.682} = 88.5$$

CHKD. BY____ DATE____

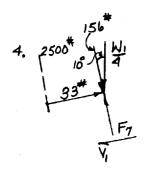
| 3. 10° Wi 488 | 2500# (Hood) |
|---------------|--------------|
| 8" 5 | 6 |
| .985 psi | |

$$W_1 = \frac{29.5}{12} \times 210 = 516^{\#}$$
 (WEIGHT OF ABOVE SECT.)

 $F_5 = 191 + \frac{516}{4} \cos 10^{\circ} + 88.5 \sin 37^{\circ} + 2500$
 $F_6 = 2871^{\#}$

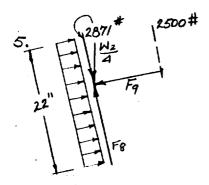
$$F_6 = \frac{8 \times 52 \times .985}{2} - \frac{516}{4} \text{ SIN 10}^{\circ} - 88.500$370$$

$$F_6 = 33^{\#}$$



$$F_7 = 156 + 2500 + 546 \cos 10^\circ = 2783^\#$$

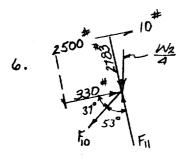
 $V_1 = 33^\# - 516 \sin 10^\circ = 10^\#$



$$W_2 = \frac{1/6}{12} \times 290 = 387^{\#}$$

$$F_8 = 2871 + \frac{387}{4} \cos 10^{\circ} + 2500 = \frac{5466}{4}$$

$$F_9 = \frac{22 \times 32 \times .985}{2} - \frac{387}{4} \sin 10^{\circ} = 330^{\#}$$



$$F_{10} = \frac{330 + 10 - \frac{381}{4} \text{ SINIO}^{\circ}}{\cos 37^{\circ}} = 404^{\#}$$

$$F_{11} = 2500 + 2783 + \frac{387}{4} \cos 0^{\circ} + F_{10} \sin 37^{\circ}$$

7. 5466# 7. 197° 404# 28" 737° F₃

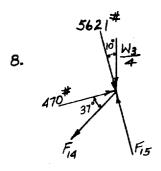
$$W_3 = \frac{28 \times 290}{12} = 677$$

$$F_{12} = 5466 + \frac{671}{4} \cos 10^{\circ} - 404 \sin 37^{\circ}$$

$$F_{12} = 5390^{\#}$$

$$F_{13} = \frac{28 \times 32 \times .985}{2} + 404 \cos 37^{\circ} - \frac{677}{4} \sin 10^{\circ}$$

$$F_{13} = 470^{\#}$$



$$F_{14} = \frac{470 - \frac{677}{4} \text{ SIN 10}^{\circ}}{\cos 37^{\circ}} = 550 \text{ } \pm 600 \text{ }$$

$$F_{15} = 5621 + \frac{677}{4} \cos 10^{\circ} + F_{14} \sin 37^{\circ}$$

 $F_{15} = 6118^{\#}$

$$W_4 = W_3 = 677^{\#}$$
 $F_{16} = 5390 + \frac{677}{4} \cos 10^{\circ} - 550 \sin 37^{\circ}$

$$F_{14} = 5225 #$$

$$F_{17} = \frac{28 \times 32 \times .985}{2} + 550 \cos 37^{\circ} - \frac{677}{4} SIN 10^{\circ}$$

$$F_{18} = \frac{852 - \frac{677}{4} \text{ S/N/0}^{\circ}}{C0537^{\circ}} = 1030^{\#}$$

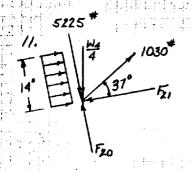
 $F_{17} = 852^{\#}$

$$F_{19} = 6118 + \frac{677}{4} \cos 10^{\circ} + F_{18} \sin 37^{\circ}$$

 $F_{19} = 6904^{\#}$

CHKD. BY..... DATE

JOB NO.____



$$F_{20} = 4770$$

$$F_{21} = \frac{14 \times 32 \times .985}{2} + 1030 \cos 37^{\circ} - \frac{617}{4} \text{ SINIO}^{\circ}$$

$$F_{23} = 6904 + \frac{677}{4} \cos 10^{\circ} = 7070 + \frac{1}{4}$$

| A Y | لخذشندي | BAT | E | |
|------------|---------|-----|---|--|
| анкр. | Y | DAT | E | |

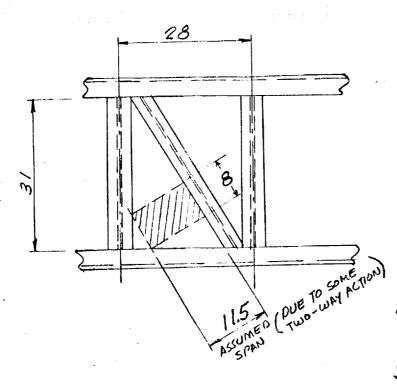
ARM, TAIL SERVICE

JOB NO......

SKIN PLATE

DESIGN PRESSURE = 21 psia REFERENCE:

MEMORANDUM TO MR. TRAVIS, LO-DE 22 FROM CHIEF, PROPULSION AND MECHANICS BRANCH, M-P&VE-P, DATED SEPT. 11, 1963; / TEM 4.



REFERENCE: SPECS, FOR STEEL RAILROAD BRIDGES SEC. A, 47(b).

PITCH (FOR SEALING) = 4+4t

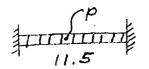
WHERE t = THICKNESS OF

THINNER SECTION

P = 4+4×3/16 = 43/4 INCH

: MAX. SPACING FOR SKIN

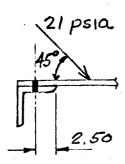
PLATE BOLTS = $4^{3}/4$ INCH



ASSUME EACH END
IS FIXED DUE TO
STITCHING EFFECT OF
BOLTS.

$$p = 21 psia - 14.7 psia$$

 $p = 6.3 psi$
 $M = \frac{p \ell^2}{12} = \frac{6.3 \times 11.5}{12} = 69.5$
USE ASTM A-36 STEEL TO
 $f = 12 \text{ KSI}$ ALLOWABLE
 $S(REQ'D) = \frac{M}{f}$
 $S = \frac{69.5}{12,000} = 0.0058$



MOMENT = G9.5 INCH - LBS/INCH

MAX. BOLT SPACING = $4^{3}/4$ INCH

MOMENT RESISTED BY EACH BOLT: $M = 4.75 \times 69.5 = 330$ INCH-LBS

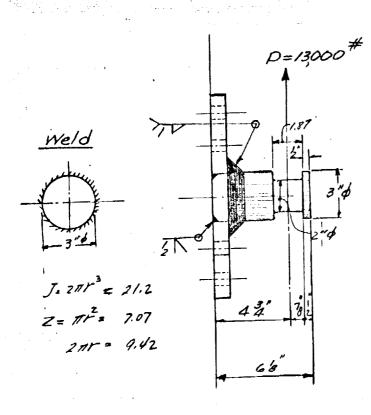
TENSION /BOLT = $\frac{330}{2.50} = 132$ LBS.

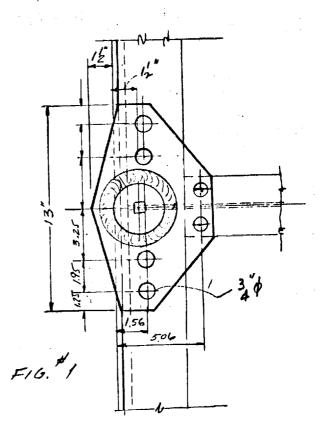
 $F_t = ALLOWABLE TENSION STRESS$ MIN. TENSION STRENGTH = /20 KSI
USE SAFETY FACTOR = 3 $F_t = \frac{120}{3} = 40 \text{ KSI}$ NET AREA OF 4 INCH DIA BOUT = .027 $f_t = ACTUAL TENSION STRESS$ $f_t = \frac{132}{1027} = 4900 \text{ psi } <40 \text{ KSI}$ OK

MAX. PURGE PRESSURE = 2.5 psi, Panel Size = 28x39 $C = Moment Coefficient = 0.072 (Ref.: ACI Blo'G Cone, Table 3, m = <math>\frac{78}{39} = 0.7$, Case 5) $M = Cwl^2$ where: w = Pressure l = 3hort Span $M = 0.072 \times 2.5 \times 28^2 = 141 INCH-POUNDS$ $S(Reg'D) = \frac{M}{f}$, f = 12,000 psi (Allowable) $S(Reg'D) = \frac{141}{12,000} = .01/7$ $S(3/6 R) = \frac{1 \times .19^2}{6} = .006 NO GOOD$ THEREFORE, 3/6 RE MUST BE BOLTED TO THE FRAME DIAGONAL TO RESIST MOMENT CAUSED

USE G-4 & BOLTS EA. DIAGONAL.

BY PURGE PRESSURE.





Mom.

Torsion
MT = 13,000 x 0.25 x 1.0 = 3250"

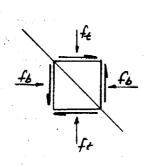
Coef. of Frich

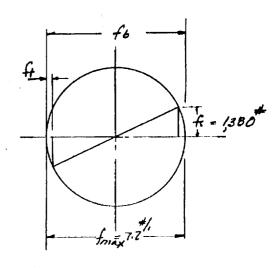
Lood on Weld

Torsion -
$$f_r = 3250 \times 1.5 = 230 \%$$
.

Bending - $f_b = \frac{48750}{7.07} = 6895 \%$.

Shear = $f_s = \frac{13,000}{9.42} = 1380 \%$.





Use I" Fillet and ' Groove weld as shown on Fig 1.

Pin

4130 Heat treated to Fy = 125,000psi Material:

Tension and Compression in Extreme fibers of Pin.

All. Fo = 0.90 Fy = 112,500 Pi

Plote

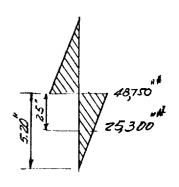
Material

$$M = 25,300"^{**}$$

$$b = 7.0$$

$$t = \sqrt{\frac{6M}{560}} = \sqrt{\frac{6 \times 25300}{22,000 \times 7}} = 0.99"$$

Use I" P.

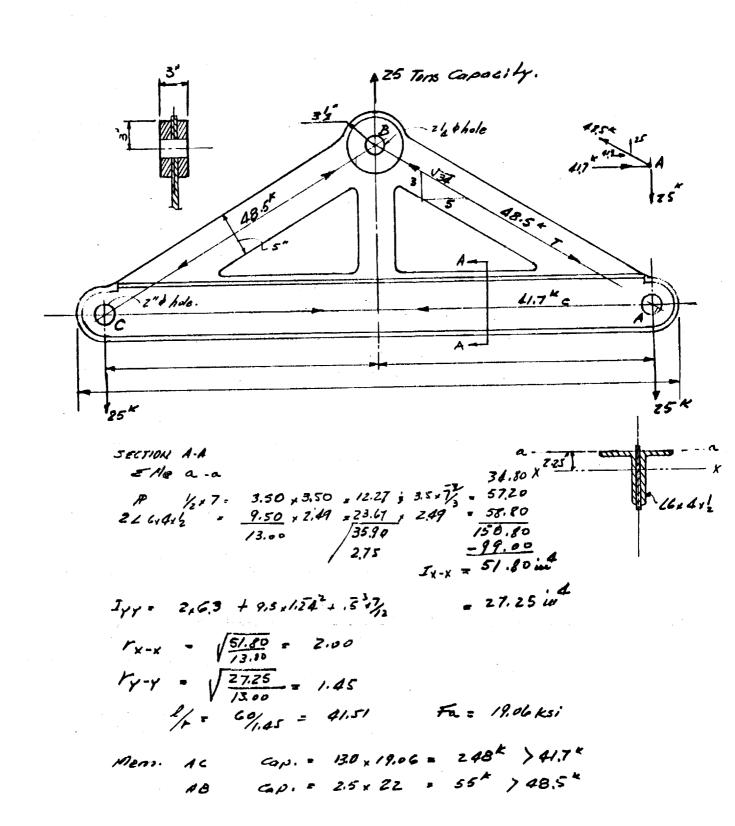


Bolts

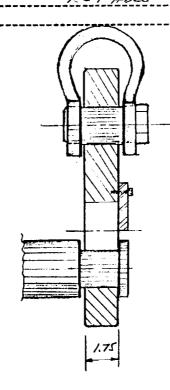
) Mast in Horiz. Position

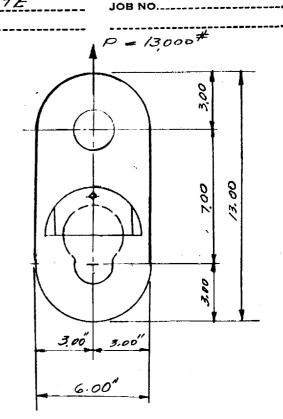
2) Most in Verl. Position

8-104



SHEET NO..... OF.....





Mot. 4130 (Annealed.)

Fy = 68,500

F= 45% Fy = 30825 psi

Check for Tension

T= 3x 1.75x 30,825 = 54.03 k > 13,000 k

Check for Bearing

Check For Ultimate shear big. foilure

Ref. Astronotic Struct. Manual Vol. II Sud. BZ

LIFTING LUG AT BASE

WELD

Assume 15 pull Horiz.

$$P = \sqrt{\frac{9.90^{2} + 1.88^{2}}{42.5}} = 10.1^{k}$$

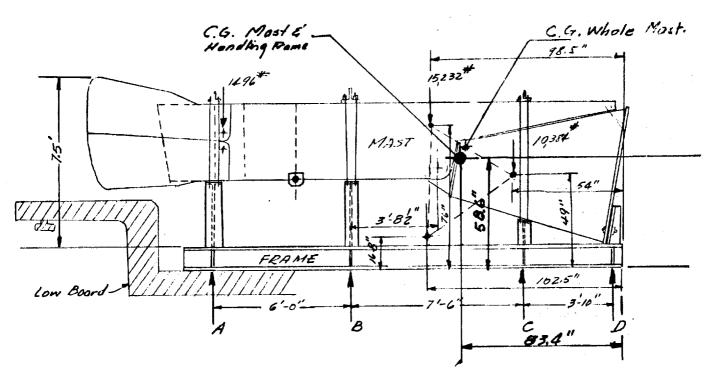
LUG Design for 15 K (NASA Monual)

$$e_0' = \frac{2.5}{2} = 1.25$$
 $\mathcal{D}_{\epsilon} = \frac{2}{1.5} = 1.33$

AISC Spec.

Use 12 P.

HANDLING FRAME



Total Most Wt.

C.G
$$\times$$
 Y

10, 384 , 54 = 560736 \times 49 = 508,816

15, 232 , 985 = 1,500, 352 \times 76 = 1,157 632

2284

2) Ann 13736

3 447 \times 102.5 = 404,568 \times 16.8 = 66 310

29,563

29,563

 \times 29,563

 \times 283.4 \times 7 = 58.6"

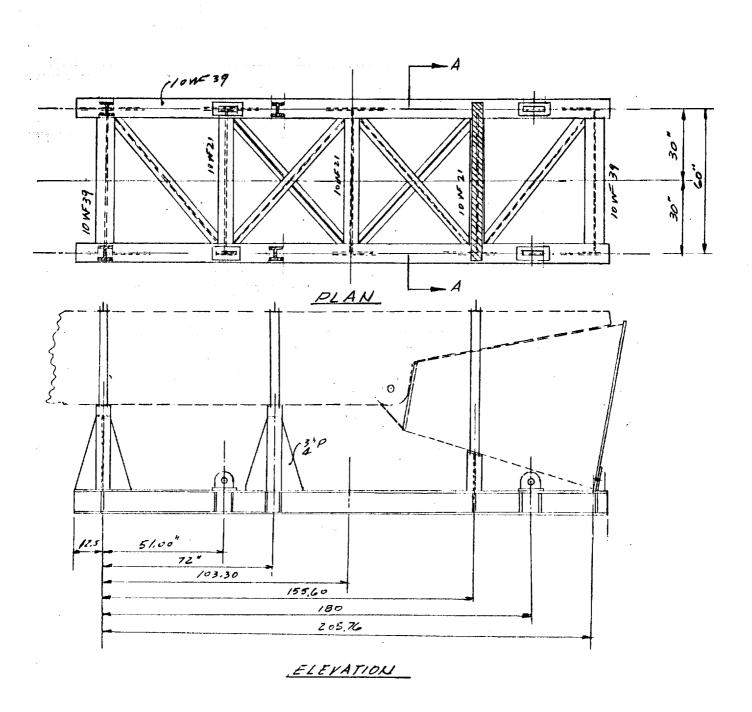
Note: The Mon. of Inertia of the most being variable and unknown, it's hard to determine Reactions AB,C &D.

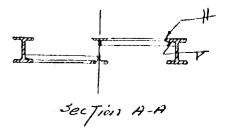
Assumption: Assume the most to be carried by Revetion

RB = Rc = 25,616 = 7 = 12,808 #

Design load: Design each support for 15,000#

| BYDATE | SUBJECT THIL SERVILE MAST | SHEET NOOF |
|--------------|---------------------------|------------|
| CHKD. BYDATE | | JOB NO |
| | HANDLING FRAME | |





CHKD. BY_____DATE____

HANDLING FRAME

Frames and Arches Reference 1 by Leontovich Pg.31

$$K = \frac{3L^2 - m^2}{4FL}$$

$$H_1 = H_4 = \frac{3M_1}{h}$$

$$\phi = \frac{60}{33} = 1.82$$

$$D = 2(1 + \frac{6}{1.82}) = 8.6$$

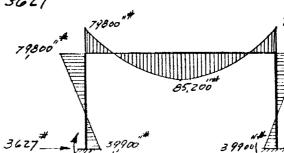
$$F = 6(2 + \frac{1}{1.82}) = 15.30$$

$$K = \frac{3\sqrt{60^2 - 32^2}}{4\sqrt{5.3}\sqrt{60}} = \frac{9776}{3672} = 2.66$$

$$M_{E} = \frac{\sqrt{(x-n)^2}}{2} + M_{Z} =$$

$$= \frac{15,000}{2} \left[30 - \left(\frac{30 \cdot 14}{32} \right)^{2} \right] + \left(-79,800 \right)$$

$$H_1 = H_4 = \frac{3 \times 39.900}{33} = 3627$$



Weld Full Penetration

(see next sheet)

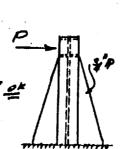
| • | SUBJECT TAIL SERVICE MAST | SHEET NO | |
|-------|---------------------------|----------|--|
| | MALALIA FOALLE | | |
| Beams | | | |

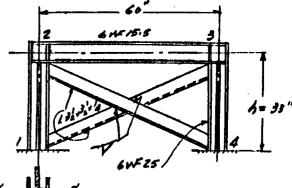
82.3

19. 85,200

Seng d. 85,200 = 387 is

6NE 15.5 3. 10.1 1787 0k





Welds

Joints OF@

M, = 39,900"#
H, = 3627#

Weld:

In = 6,2 + 12,2 = 324 ii

In = 5 + 6,3,2 = 119 iii

Lath of weld: 42"

Y-Y Axis

$$f_{5} = \frac{3627}{42} = 86 \text{ pci} \rightarrow \frac{39,900 \times 3}{119} = 1005 \text{ pci}$$

$$f_{5} = \sqrt{1005^{2} + 86^{2}} = 1100 \text{ pci}$$

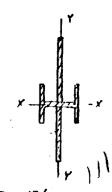
x-x Axis

Assume a load of 15th pushing longitudinally:

weld = 9160 - 78" Well.

Use Full Penetration

Bending due to Longitudino Load.



Ty-x 6W 25= 17.1

R. 3 (73) 2 864 881 in C

8-111

Diogonals

Lifting Lug

weld Brg A to Bm

weld Lug to Big A

Lath of weld = 32"

Bearing Plate

209

| BYDATE | SUBJECT | SHEET NO. OF |
|--------------|---------|--------------|
| CHKD. BYDATE | | JOB NO |

Using NASA MANUAL (Analysis of Lug Sect. BZ Z7 July 1961) 1) check for Ultimate load for shear bry, failure Para - Kor Fux Abr

$$f_{bru} = K_{br} f_{ux} A_{br}$$

 $f_{ron}, f_{ro} = 8.2.1.0.3$ $K_{br} = 1.90$
 $F_{bru} = 1.90 \times 36 \times 4 = 279 K OK$

Rope
14" b purple strond 1.W.R.C. Breaking strength = 69.4 T Safe working load = 69.4 - 13.9 Load on Rope = 29,000 = 10 + 213.9 T

```
72" 82" 51"

101 10 w 39 "11

129" — Lifting Lug.

R, R2
```

Retering to sheet /, Loads

Most =
$$26,000^{\#}$$

Frame = $4,000^{\#}$
Total = $30,000^{\#}$

- 1) Assume A, B, C and D are equal (7500 Euch)
- 2) Assume B, C only (15,000 # Each)

Case 2.

web Crippling Gnt.

All.
$$f_3 = \left[2 + \frac{4}{(94)^2}\right] = \frac{10 \cdot 10^6}{\left(\frac{9 \cdot 10^6}{5}\right)^2} = 7.07 \cdot 10 \cdot 10^6 = 8500 \text{ psi}$$

C.G. Handling Frame.

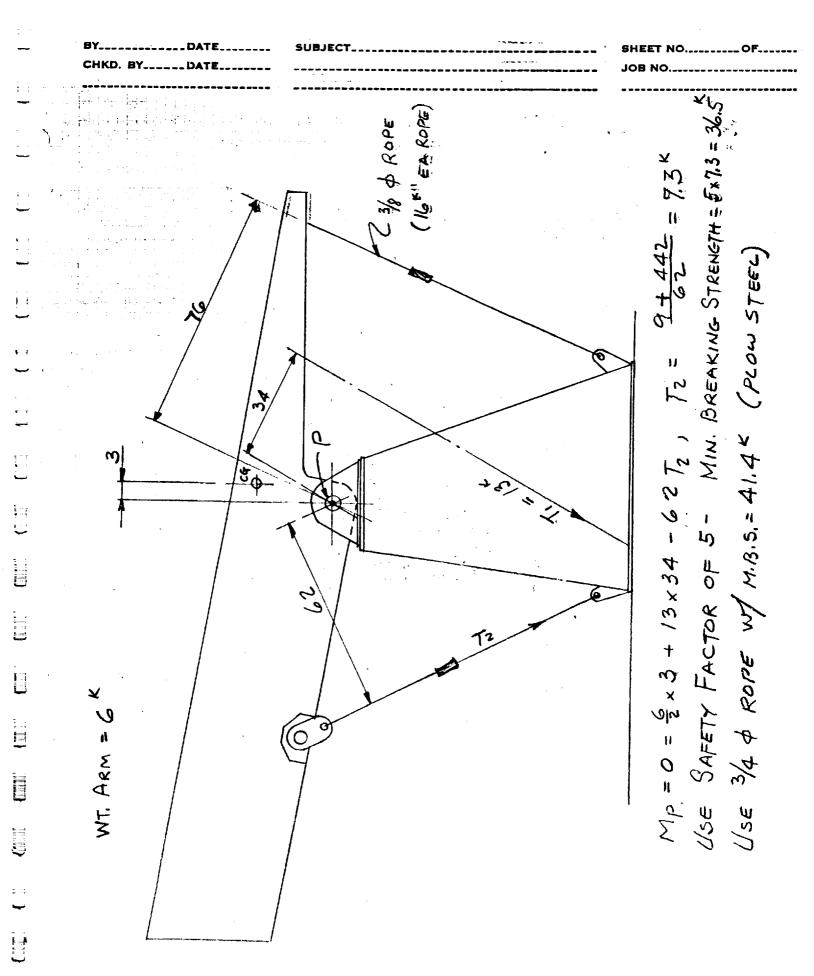
| Them Volume 7 | | | | | | |
|--|---------------|----------|---------------|--------|------------|---------------|
| 1-10W 39 4 60 688.80 5.00 5.24 3144.00 3609.3, 1-10W 39 4 60 688.80 5.00 211.00 3444.00 12474.00 1-10W 31 4 60 371.40 5.00 168.70 62395.20 1-10W 31 4 60 371.40 5.00 167.70 1857.00 33999.70 1-10W 31 4 60 371.40 5.00 167.70 1857.00 37999.70 1-10W 31 40 5.00 47.40 1857.00 17604.30 1-574.85.75 187.50 5.00 107.70 937.50 20193.71 2-1,31,49 7 31.50 5.00 107.70 937.50 1088.00 2-1,31,49 7 126.00 5.00 139.00 630.00 17514.00 2-1,31,49 7 126.00 5.00 139.00 630.00 17514.00 2-1,31,49 7 126.00 5.00 375.00 2898.00 8-1,31,49 7 126.00 5.00 375.00 2898.00 2898.00 2-1,31,49 7 126.00 5.00 375.00 23595.00 14485.50 3-1,31,40 126.00 5.00 3.50 3.50 375.00 2898.00 2-1,31,40 126.00 5.00 375.00 23595.00 14485.50 3-1,31,40 126.00 5.00 375.00 1107.24 61583.91 6-1,31,40 126.00 5.00 43.14 139.00 12855.72 62878.01 6-1,31,40 12 12 12 12 12 12 12 12 12 12 12 12 12 | Item | Volume | \ \frac{1}{2} | ₹ | į v? | VX |
| 1-10W 39 4 60 688.80 5.00 5.24 3144.00 3609.3, 1-10W 39 4 60 688.80 5.00 211.00 3444.00 12474.00 1-10W 31 4 60 371.40 5.00 168.70 62395.20 1-10W 31 4 60 371.40 5.00 167.70 1857.00 33999.70 1-10W 31 4 60 371.40 5.00 167.70 1857.00 37999.70 1-10W 31 40 5.00 47.40 1857.00 17604.30 1-574.85.75 187.50 5.00 107.70 937.50 20193.71 2-1,31,49 7 31.50 5.00 107.70 937.50 1088.00 2-1,31,49 7 126.00 5.00 139.00 630.00 17514.00 2-1,31,49 7 126.00 5.00 139.00 630.00 17514.00 2-1,31,49 7 126.00 5.00 375.00 2898.00 8-1,31,49 7 126.00 5.00 375.00 2898.00 2898.00 2-1,31,49 7 126.00 5.00 375.00 23595.00 14485.50 3-1,31,40 126.00 5.00 3.50 3.50 375.00 2898.00 2-1,31,40 126.00 5.00 375.00 23595.00 14485.50 3-1,31,40 126.00 5.00 375.00 1107.24 61583.91 6-1,31,40 126.00 5.00 43.14 139.00 12855.72 62878.01 6-1,31,40 12 12 12 12 12 12 12 12 12 12 12 12 12 | 2-10W-39 ,224 | 1 | 5.00 | 112.00 | 25,715.20 | 576016.00 |
| 1-10 W 39 + 60 688.80 5.00 211.00 3884.00 12474.00 1-10 W 21 + 60 371.40 5.00 168.00 1857.00 62395.20 1. 371.40 5.00 107.70 1857.00 37999.70 1. 371.40 5.00 107.70 1857.00 37999.70 1. 371.40 5.00 107.70 1857.00 37999.70 1. 371.40 5.00 107.70 937.50 20193.71 2-1,31.49 31.50 5.00 211.00 157.50 6666.00 2-1,31.49 166.00 5.00 139.00 630.00 17518.00 2-1,31.49 176.00 5.00 139.00 630.00 17518.00 2-1,31.49 176.00 5.00 139.00 630.00 17518.00 2-1,31.49 163.00 5.00 33.00 630.00 2898.00 2-1,01.31.40 1686.50 24.37 211.00 23595.00 14885.55 2-1,131.40 1686.50 24.37 139.00 23595.00 14885.55 2-1,131.40 143.05 25.07 211.00 1107.26 93483.55 2-1,131.40 143.05 25.07 211.00 1107.26 93483.55 2-1,131.40 143.05 25.07 211.00 1107.26 61583.91 2-1,131.40 143.05 25.07 211.00 1107.26 61583.91 2-1,131.40 143.05 25.00 139.00 12855.72 62878.00 2-1,21,555.88 55.00 43.14 139.00 12855.72 62878.00 2-1,21,555.88 55.00 43.14 139.00 12855.72 62878.00 2-1,21,555.88 55.00 43.14 139.00 12855.72 1462.00 2-1,21,21,21,21,21,21,21,21,21,21,21,21,21 | | 688.80 | 5.00 | l . | , , | 3609.31 |
| 1-10 well x 60 371.40 5.00 168.00 1857.00 62395.20 1 | | l l | 5.00 | | 3444,00 | I . |
| 371.40 5.00 107.70 1857.00 39999.70 371.40 5.00 47.40 1857.00 17604.30 4-574.85.75 187.50 5.00 107.70 937.50 20193.71 2-1,31.9 | | 3 | | | · | 1 |
| 37/.40 5.00 47.40 1857.00 176.04 36 d-574.85.75 187.50 5.00 107.70 937.50 20193.71 2. 1, 31.49 7 31.50 5.00 107.70 937.50 20193.71 2. 1, 31.49 7 31.50 5.00 121.00 157.50 1046.00 8. 1, 31.49 , 126.00 5.00 139.00 630.00 17514.00 2. 1, 31.49 , 126.00 5.00 47.40 157.50 1493.10 8. 1, 31.49 , 126.00 5.00 33.00 23.00 2898.00 4. 1, 31.49 , 126.00 5.00 33.00 23.50.00 2898.00 3. 1. 120.00 3.00 3.50 33.50 0 23.50 14485.15 3. 1. 120.00 3.00 3.50 33.50 0 14485.15 6. 1. 120.00 3.00 3.50 1107.26 61583.91 6. 1. 120.00 43.14 139.00 12855.72 62878.00 1. 1. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | 1 | | | 1 | į. |
| d-574,85,75 187.50 5.00 107.70 937.50 20193.75 20193.7 | | 1 | 1 | | 1 | 1 |
| $2 \cdot 1, 3 \cdot 1 \cdot 9$ 31.50 5.00 211.00 157.50 646.00 $6-\frac{1}{4}, 3\frac{1}{4} \cdot 9$ 63.00 5.00 168.00 315.00 10586.00 $8 \cdot \frac{1}{4}, \frac{3}{4} \cdot 9$ 126.00 5.00 139.00 630.00 17516.00 $2 \cdot \frac{1}{2}, \frac{3}{4} \cdot 9$ 126.00 5.00 47.40 157.50 1493.10 $4 \cdot \frac{1}{4}, \frac{3}{4} \cdot 9$ 126.00 5.00 23.00 2898.00 2898.00 $4 \cdot \frac{1}{4}, \frac{3}{4} \cdot 9$ 126.00 5.00 23.00 23.50 221.00 $4 \cdot \frac{1}{4}, \frac{3}{4} \cdot 9$ 126.00 5.00 3.50 315.00 221.00 $4 \cdot \frac{1}{4}, \frac{3}{4} \cdot 9$ 126.00 5.00 3.50 315.00 221.00 $4 \cdot \frac{1}{4}, \frac{3}{4} \cdot 9$ 126.00 3.50 3.50 315.00 221.00 $4 \cdot \frac{1}{4} \cdot \frac{3}{4} \cdot 9$ 1285.00 $4 \cdot \frac{1}{4} \cdot \frac{3}{4} \cdot 9$ 1285.00 $4 \cdot \frac{1}{4} \cdot \frac{3}{4} \cdot 9$ 1285.00 43.14 43.05 25.07 139.00 1107.26 13483.53 143.00 143.05 143.06 143.06 143.07 144.08 143.08 143.09 143.09 144.09 144.09 143.09 144.09 | | 1 | | • | 1 | |
| 4-1,31,49 | | 31.50 | , , | | | 1 |
| $8 - \frac{1}{2} \times 3\frac{1}{2} \times 9$. | | • | | | | 1 . |
| $2 - \frac{1}{2} \times \frac{3}{4} \times \frac{9}{9}$ 31.50 5.00 47.40 157.50 1493.10 $8 - \frac{1}{4} \times \frac{3}{4} \times \frac{9}{9}$ 63.00 5.00 3.00 30.00 2898.00 $4 \cdot \frac{1}{4} \times \frac{3}{4} \times \frac{9}{9}$ 63.00 5.00 3.50 315.00 271.00 315.00 271.00 315.00 271.00 315.00 271.00 315.00 310.00 31 | | 1 | ! ! | | | 1 |
| 8-1x3!x9 | _ | 1 | l i | | 1 | 1 |
| 4-1 x 31, 16 88. 1513. d. 36 686. 50 24. 37 211.00 23595.00 14485.15 686. 50 24. 37 139.00 23515.00 95423. 53 686. 50 24. 37 139.00 23515.00 95423. 53 686. 50 24. 37 139.00 23515.00 95423. 53 686. 50 24. 37 139.00 1107. 26 11583. 92 1107. 26 11583. 92 1107. 26 11583. 92 1107. 26 11583. 92 1107. 26 11583. 92 1107. 26 1107. 27 1107. 26 1107. 27 1107. 26 1107. 27 | | 1 | | | 1 | I . |
| 8. P. 1543, d. 36 6. 86. 50 24. 37 139.00 23595.00 14485.15 6. 68. 50 24. 37 139.00 23595.00 95423.50 6. 68. 50 24. 57 21. 00 11.07.26 93. 483.53 4. 3. 05 25. 07 21. 00 11.07.26 12.855.72 11.05.00 11.07.26 12.855.72 11.05.00 11.07.26 11.05.00 11.07.26 11.07.27 11.07.26 11.07.26 11.07.26 11.07.26 11.07.26 11.07.26 11.07.27 11.07.26 11.07.27 11.07.27 11.07.27 11.07.27 11.07. | _ | 1 | 1 | | } | 1 |
| 686.50 24.37 139.00 23575.00 95423.50 6W 25 x 2 x 3 a 14 443.05 25.07 211.00 11107.26 93 483.53 6W 25 x 2 x 3 a 14 443.05 25.07 139.00 11107.26 61583.93 6W 25 x 44.5 278.00 43.14 211.00 12855.72 62878.00 6 x 3 278.00 43.14 211.00 12855.72 62878.00 6 x 4 1 278.00 43.14 139.00 12855.72 61422.00 6 x 4 1 55.00 43.14 139.00 12855.72 61422.00 6 x 4 1 55.00 43.14 139.00 2372.70 116.05.00 6 x 4 1 155.00 43.14 139.00 2372.70 116.05.00 6 x 4 1 157.00 2372.70 116.05.00 6 x 4 1 157.00 2372.70 116.05.00 6 x 1 1 172.80 25.00 139.00 4320.00 24019.20 6 x 1 1 188.40 12.92 168.00 1917.33 34132.00 6 x 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | 1 | 1 | | i | |
| $6W25 \times 2.3014$ 443.05 25.07 $2/1.00$ $1/107.26$ 93483.55 443.05 25.07 139.00 $1/107.26$ 61583.9 $6W5/5.5 \times 64.5$ 298.00 43.14 211.00 12855.72 62878.00 43.14 139.00 12855.72 $148.20.00$ 1585.72 1685.00 172.80 | 9 | 1 | l . | _ | l e | 1 |
| 443.05 25.07 139.00 11107.26 61583.9. LWF15.5, LA.5 278.00 43.14 211.00 12855.72 62878.01 298.00 43.14 139.00 12855.72 41422.00 2x21, 5.5 x8 55.00 43.14 211.00 2372.70 11605.00 2x21, 5.5 x8 55.00 43.14 139.00 2372.70 11605.00 223x3x4x60 172.80 25.00 211.00 4320.00 36460.80 4 7 7 172.80 25.00 139.00 4320.00 24019.20 2409 37.10x18x2 148.40 12.92 168.00 1917.33 34132.00 24 81x4x62 395.25 14.25 6.20 5532.31 2451.00 24 81x5x1x6 54.00 12.00 5.00 648.00 270.00 24 92.00 50.00 47.40 346.80 3287.60 24 14 15 16 16 16 16 16 16 16 16 16 16 16 16 16 | | !!! | | | | 1 |
| 298.00 43.14 211.00 12855.72 62878.00 43.14 139.00 12855.72 41422.00 $12.212.55 \times 8$ $14.212.00$ 139.00 12855.72 $114.22.00$ $12.212.55 \times 8$ $14.212.00$ 116.05×100 $116.05 \times $ | | 443.05 | 25.07 | | | 1 |
| 298.00 43.14 139.00 12855.72 41422.00 $222_{1}^{2},5.5 \times 8$ 55.00 43.14 211.00 2372.70 11605.00 4.1 1 55.00 43.14 137.00 2372.70 7645.00 $223_{1},3_{1},4_{1},60$ 172.80 25.00 211.00 4320.00 36460.80 172.80 25.00 139.00 4320.00 24019.20 1917.33 1919.30 1917.33 1919.30 1917.33 1919.30 1917.33 1919.30 1917.33 1919.30 1917.33 1919.30 1919.30 1919 | | 1 (| | • | 1 | |
| $\frac{1}{2} \times \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{5}{2} \times \frac{8}{2}$ $\frac{1}{2} \times \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{5}{2} \times \frac{8}{2}$ $\frac{1}{2} \times \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \times \frac{1}$ | | 1 | | | l . | I . |
| 35.00 43.14 39.00 2372.70 7645.00 $2/3x3x/y 60$ 172.80 25.00 $2/1.00$ 4320.00 36460.80 $37.10x/x 2$ 148.40 12.92 168.00 1917.33 34132.00 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.90 1917.33 34132.00 $18.47.5x/2 60$ $18.47.5x/2 60$ 18.40 | | 1 : | | • | i | 1 |
| $2 \angle 3_3 3_3 4_4 60$ | | 1 3 | 1 | | į . | l . |
| 772.80 25.00 139.00 4320.00 $240/9.20$ $240/9.20$ $37.10 \times 176 \times 2$ 148.40 12.92 168.00 1917.33 $34/32.00$ 92×148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 12.92 148.40 149.40 | _ | 1 | I | | i e | 1 |
| 249 37.10×1/8×2 148.00 12.92 168.00 1917.33 24931.20 148.40 12.92 23.00 1917.33 36132.00 148.40 12.92 23.00 1917.33 36132.00 148.40 12.92 23.00 1917.33 36132.00 148.40 12.92 6.20 5632.31 2651.00 148.40 12.00 5.00 648.00 270.00 148.40 12.00 5.00 648.00 270.00 148.40 12.00 5.00 648.00 3287.60 148.40 17.00 47.40 346.80 3287.60 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 16824.10 1785.00 4977.00 1785.00 4977.00 1785.00 4977.00 1786.00 24.25 47.40 2401.50 9385.20 273.00 76.41 139.00 20859.93 37947.00 273.00 76.41 139.00 20859.93 37947.00 18931.95 263.00 76.41 47.40 20095.83 12466.20 | | 1 | - 1 | | 1 | 1 |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | _ | 1 | - 1 | | 1 ' | f . |
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| P 8 x 4.75 x 1 x 6 P 6 x 4.75 x 1 x 6 P 7 x 6 x 6 x 6 x 6 x 6 x 6 x 6 x 6 x 6 x | | . , | • | | 1 | |
| P 6, 2, 2, 2, 49 69 36 5,00 47 40 346.80 3287 .60 P 30, 14, 66 346.50 17.00 47.40 5890.50 16824 10 P 12 x 6 x 14 x 2 84.00 17.00 47.40 1428.00 3981 .60 P 12 x 6 x 66 105.00 17.00 47.40 1785.00 4977 .00 P 12 x 6 x 66 198.00 24.25 47.40 2401.50 9385.20 576 WF 13.5 x 47.50 273.00 76.41 211.00 20859.93 37947.00 273.00 76.41 139.00 20859.93 37947.00 263.00 76.41 47.40 20095.83 12466.20 | | 1 | | | | |
| P 3, 14, 66 P 1, x6 x 10x2 P 1, x2 x 11 x 6 P 2, x 6 x 64 P 3, 00 P 3, | | 1 | | | L | 1 |
| P 12 x 6 x 1 a x 2 | P 30 14 66 | 1 . 1 | | | | 1 |
| 9 1, 421, 14,6 105.00 17.00 47.40 1785.00 4977.00 9 1, 4 21, 14,6 105.00 17.00 47.40 1785.00 4977.00 9385.20 576 NF 13.5 x 47.50 273.00 76.41 211.00 20859.93 37947.00 263.00 76.41 47.40 20095.83 17466.20 13931.95 233,600.53 1,428,460.46 | | \$4,00 | 17.00 | | | _ |
| \$76 NF 13.5 x 47.50 | | 1 | | - | | j _ |
| \$76 NF /3.5 \ 47.50 \ 273.00 \ 76.4/ \ 211.00 \ 20859.93 \ 57603.00 \ 76.4/ \ 131.00 \ 20859.93 \ 37947.00 \ 263.00 \ 76.4/ \ 47.40 \ 20095.83 \ 12466.20 \ 13931.95 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ | | 1 | 24.25 | | | 1 |
| 273.00 76.41 139.00 20859.93 37967.00 263.00 76.41 47.40 20095.83 12466.20 13931.95 233,600.53 1,428,460.46 | | 273,00 | 76.41 | | | , , |
| 263.00 76.41 47.40 20095.83 12466.20 13931.95 233,600.53 1,428,460.44 | | 1 | 1 | | • | <u> </u> |
| | 1 1166 | 1 1 | · · | | | |
| 16.77" 10Z. 53" | | 13931.95 | | | 233,600.53 | 1,428, 460.44 |
| | | | , | | 16.77" | 10Z. 53" |
| | _ | | | | | |

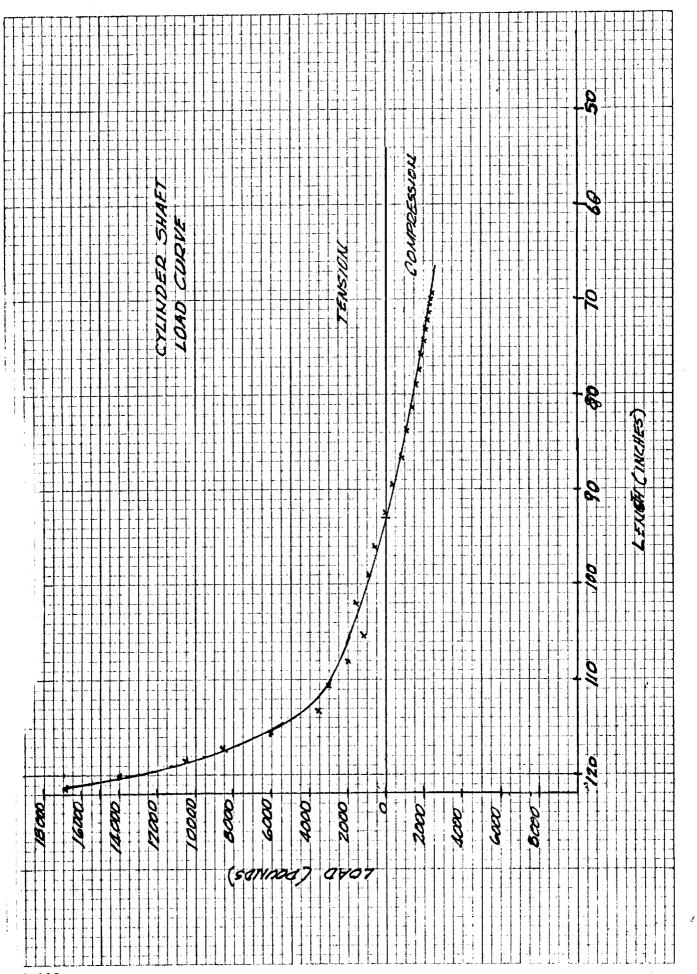
Wt. = 3947.4#

Each Rope = 52#

4 = 205#

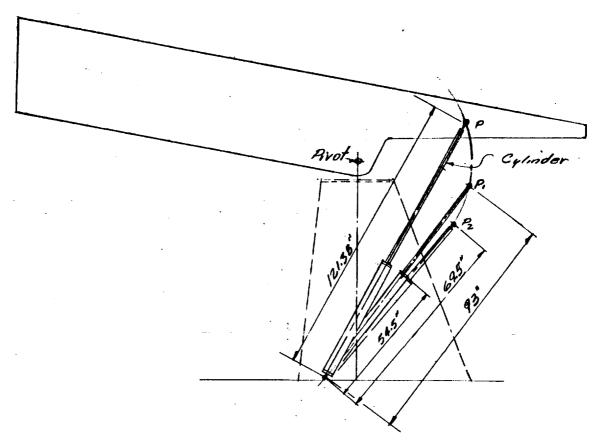
wt. of spread beam = 267# each.





8-118

Hydraulic Cylinder



Cylinder Position

- P Innitial Position; Cylinder in Tension
- P, load converts from Tension to Compression
- P2 Max. Compression load on Cylinder shoft.

Cylinder Dota.

Double acting

Shoke - 53"

Bore = 3.25" Dioni

Rod = 2" \$

Operating Pressure = 0-3000 PSIG.

Proof Pressure = 4500psig.

Burst Pressure = 7500 PSIG.

Moterial

Rod: Chrome Plated, 90,000, to 100,000 pic Y.P.

3/30/64

```
Max Axial load

Tension = 17,000 & Both Cylinder

Compression = 2550
```

. Piston Rod 1.

$$2^{n} H$$

Avea = 3.14 in

 $1 = 7854 R^{4} = .7854 in$
 $= 0.5 in/n$

Allowable Tension in Rod.

$$F_{\tau} = 0.60 F_{\gamma} = 0.60 \times 90,000 = 54,000 psi$$
 $T = 3.14 \times 54,000 psi = 170,000 \ > 17,000 psi 0k.$
 $S.F = \frac{170,000}{17,000} = (10.0)$

Allowable Compression is Rod.

$$C_{c} = \sqrt{\frac{2\pi^{2}E}{F_{Y}}}$$

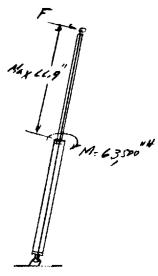
$$C_{c} = \sqrt{\frac{2\pi^{2}x30_{x}10^{6}}{7.0x10^{4}}} = 81.7 \text{ [158]}$$

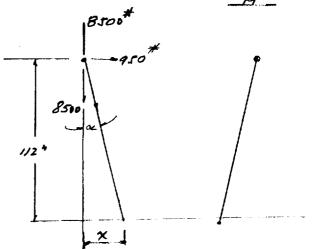
$$Fa = \frac{149 \times 10^6}{(158)^2} = 5970 \text{ psi}$$

@ 4 = 70"

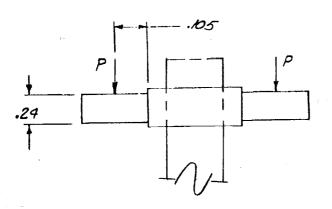
$$fa = \frac{149 \times 10^6}{(119)^2} = 10500 PSi$$

Allowable Bending in Pod.





this shows that the Cylinder con move 13.4" out of Position before Bending Occur @ Rod.



$$A = \frac{\pi(2a)^2}{4} = .045$$
 $I = \frac{\pi d^4}{69} = \frac{\pi(.29)^4}{69} = .000163$

$$S = \frac{MC}{T} = \frac{.105 \times 81.25 \times .24}{.63 \times 10^{-4}} = 7325 \frac{4}{10^{2}}$$

$$f(MAX) = \frac{3}{2} + \sqrt{(\frac{5}{2})^2 + V^2} = \frac{7325}{2} + \sqrt{(7525)^2 + (1505)^2}$$

SECTION IX SCHEDULES

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TAIL SERVICE MAST SCHEDULE

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| | 7 90 7 | A | | | | | | | | | | | |
|----------------------------|---------|-------------|---------------------------------------|----------------------------|--|--|--|--|---|--|-------------------------------|---|--|
| | | NDJF | | | | | | - | | | | | |
| SATURN V | 996 | OSALL | 4 | | | DWARE | ARES | | | | | | |
| ILE | | A M F L C | | | | AI SET (3 HOUSINGS) FLIGHT HARDWARE | USINGS) FLIGHT SP. | | | | | | |
| r SCHEDU | 9 | O S A | | | HAROWARE | ■ SET (3 HOU! | C 36 15 16 HG | | INGS) T | | | | HARDWARE (3 HOUSINGS) - |
| TAIL SERVICE MAST SCHEDULE | 1965 | T A M | (PROTOTYPE) | A PLATE (PROTOTIVES) | SET (3 HOUSING) FLIGHT TEST HARDWARE | | | | ONE SET OF FLIGHT HARDWARE (3 HOUSINGS) | | | | - 1000 |
| TAIL SERI | | 7 0 N | EMG (LOX) HOUSING & PLATE (PROTOTYPE) | ■ BOEING (AR COND) HOUSING | — ₽ — ₽ — ₽ | | | | ONE SET OF FLIGHT | | | | |
| | 1964 | 4 7 2 | A BOEING (LOX) HOUSE | A BOE 146 | 1 | | | | | | | | |
| | | 7 | | | | 4 | 4 | = | | | | 1 | |
| | 11 6 21 | | | | TAL SERVICE MAST (PROTOTYPE) S/N-1000 | TAIL SERVICE MAST (3-4)(LDX) S/N+1001 | TAIL SERVICE MAST (1-2) (FUEL) S/N-1002 | TAIL SERVICE MAST (3-2) (AIR COND) S/N-1003 | TAIL SERVICE MAST (3-4)(LOX) S/N-1004 TAIL SERVICE MAST (1-2)(FUEL) S/N-1005 | TAIL SERVICE MAST (3-2) (AIR COND) S/N-1006 | TAIL SERVICE MAST (3-4) (LOX) | TAIL SERVICE MAST (1-2)(FUEL) S/N-1008 | TAIL SERVICE MAST (3-2) (AIR COND) S/N-1009 |
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TESTAGO

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ADVERTISE & AMAND

LEGEND

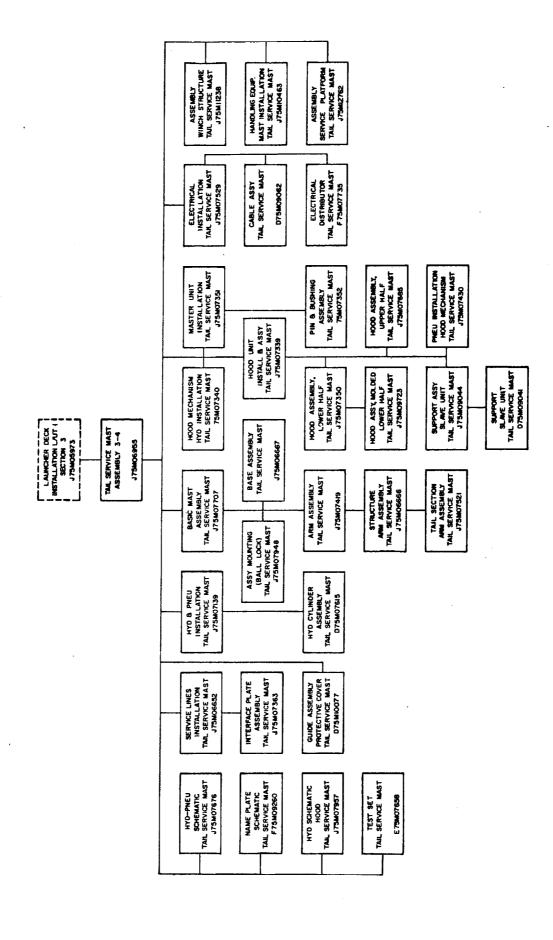
9-1

SECTION X DRAWING BREAKDOWN

- 10-1 STRUCTURES
- 10-2 HOOD DRAWINGS
- 10-3 UMBILICAL WINCH
- 10-4 SERVICE LINES
- 10-5 HANDLING EQUIPMENT
- 10-6 HYDRAULICS
- 10-7 ELECTRICAL

- 10-1A

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Tail Service Mast drawing breakdown Assemblies & Sub Assemblies Fig. 10-1

SECTION X TAIL SERVICE MAST DRAWING LIST

10-1 STRUCTURES

```
J75M06953 Assembly, TSM, 1-2
 J75M06957 Assembly, TSM, 3-2
 J75M06955
           Assembly, TSM, 3-4
 J75M06667
           Assembly, Base, TSM
D75M09850 Angle, Assy, TSM
 J75M07419
           Arm, Assembly, TSM
 J75M07341 Ball Lock, TSM
J75M07707 Basic Mast Assembly, TSM
B75M10312 Bearing, Guide Assy, TSM
C75M07949 Bolt, Receptacle, TSM
D75M10076 Bracket, Limit Switch, TSM
C75MO7422 Bushing, Pivot, TSM
B75M11794 Check Valve, Purge TSM
J75M07354 Cover, Master Unit, TSM
C75MO9254 Dyna-Therm, Application Spec, TSM
D75M10077 Guide Assy, Protective Cover, TSM
B75M10099 Guide, Protective Cover, TSM
D75M07950 Housing, Ball-Lock, TSM
J75M07948 Installation, Ball-Lock, TSM
D75M10078 Lock, Protective Cover, TSM
J75M07420
          Lug, Machining, TSM
D75M07952 Plate, Cover, TSM
C75M11793 Plate, Keyhole, TSM
C75M10050 Plate, Mounting, TSM
B75M10098 Pin, Guide Assy, TSM
C75M07421 Pin, Pivot, TSM
C75M10079 Pin, Protective Cover, TSM
J75M07424 Protective Cover, Assembly, TSM
D75M07951 Receptacle, Ball-Lock, TSM
B75M12101
          Shim, Valve Support, TSM
B75M07404
          Spring Extension Modification, TSM
J75M12102 Support, Lox Valve, TSM
J75M06666 Structural Assembly, Arm, TSM
J75M07521
          Tail Section, Arm Assembly, Details, TSM
C75MO7423
          Thrust Washer, Pivot, TSM
D75M11792 Wire Rope, Tie Down, TSM
```

10-2 HOOD DWGS.

```
Accumulator, Hydraulic 58 Cum., TSM
B 75M07628
            Angle, Slave Unit, TSM
C 75M09154
            Angle Bracket, TSM
B 75M10041
            Angle Support, TSM
B 75M10042
            Ball Lock, TSM
B 75M07341
            Boss, Hood To Slave Unit, TSM
D 75M07359
            Bushing, Slave Unit, TSM
C 75M07686
            Bushing, Master Unit, TSM
C 75M07356
            Bracket Support, TSM
B 75M10044
            Bracket, TSM
D 75M07954
            Bracket, TSM
C 75M10049
            Bracket, TSM
B 75M10046
            Bracket, Quick Disconnect, TSM
C 75M07428
            Cap, Protective, Slave Unit, TSM
C 75M07680
            Cam, Hyd. Installation, TSM
D 75M07687
            Clamp, 1/2 Tubing, TSM
D 75M07683
            Coupling Assy., Quick Disconnect, TSM
B 75M07517
            Gauge-Pressure 0-200 PSI
B 75M07632
            Gear, Slave Unit, TSM
D 75M07346
            Grommet Modification, TSM
B 75M10043
            Hood Assy, Lower Half, TSM
J 75M07350
            Hood Assy, Molded Lower Half, TSM
J 75M09723
            Hood Assy, Molded Upper Half, TSM
J 75M09724
            Hood Assy, Upper Half, TSM
J 75M07685
            Hood Mech., Hydraulic Installation, TSM
J875M07340
            Hood Unit Installation & Assy, TSM
J-75M07339
            Housing, Hood Locking Mech., TSM
C 75M07817
            Hose Assy, TSM
D 75M07344
            Hydraulic Schematic, Hood, TSM
J 75M07957
            Key, Master Unit, TSM
B 75M09043
            Lever, Torque Transfer, Master Actuator, TSM
D 75M07355
            Master Unit Installation, TSM
J 75M07351
            Pad, Accumulator, TSM
B 75M10045
             Pad, Accumulator, TSM
B 75M10047
             Pin and Bushing Assy, TSM
C 75M07352
            Pin, Master Unit, TSM
C 75M07358
             Plug, Hood Detachment, TSM
D 75M07681
             Pneumatic Installation, TSM
J 75M07430
             Receiver, Hood Locking Mech., TSM
C 75M07817
             Rotary Act., Slave, TSM
B 75M07626
             Rotary Actuator, Master, TSM
B 75M07622
             Seal, Hood, TSM
 C 75M09155
             Seal, Hood, TSM
 C 75M09156
             Seal, Hood, TSM
 C 75M09157
```

10-2 HOOD DWGS. (Continued)

D 75M07357 Shaft, Slave Unit, TSM B 75M10091 Shim, Ball Lock, TSM B 75M09042 Spacer, Slave Unit, TSM C 75M10048 Strap, Accumulator, TSM J 75M09044 Support Assy, Slave Unit, TSM C 75M07427 Support, Bracket, TSM C 75M07353 Support, Master Actuator, TSM D 75M09041 Support, Slave Unit, TSM D 75M07429 Support, Quick Disconnect, TSM B 75M07958 Tee, Reducer, TSM B 75M07955 Tee, TSM B 75M07956 Tee, TSM C 75M07347 Thrust Washer, Slave Unit, TSM D 75M07876 Tubing Assy, Hyd. Installation, TSM B 75M07953 Union, Flare Tube, TSM B 75M10205 Valve - 1/2 Check, TSM B 75M07627 Valve-1/2", Flow Control with Check, TSM Valve - 1/2 Hyd. Pressure Relief, TSM B 75M10206 B 75M07624 Valve - 1/4 inch, Hyd. Check, TSM

10-3 UMBILICAL WINCH

14

B 75M11248 Air Control Valve, TSM
J 75M11238 Assembly, Winch Structure, TSM
D 75M11241 Hose Assembly, TSM
B 75M11247 Pneumatic Cylinder, TSM
C 75M11246 Rod Eye, Winch Structure, TSM
C 75M11244 Sheave, Bushing, Winch Structure, TSM
D 75M11243 Sheave Guard, Winch Structure, TSM
C 75M11240 Sheave, Winch Structure, TSM
C 75M11245 Thrust Washer, Winch Structure, TSM
J 75M11239 Winch Structure, TSM
C 75M11245 Wire Rope Assy, Winch Structure, TSM

B 75M07625 Valve, 4-way, 3 position, CAM, TSM

10-4 SERVICE LINES

C 75M11930 Adapter, 1" Nozzle, TSM Angle Support Assembly, TSM #1-2 D 75M11927 Angle Support, TSM #1-2 D 75M08658 Assy, Interface Plate, TSM #1-2 J 75MO9409 Assembly, Interface Plate, TSM #3-2 J 75MO8655 Base Alignment Guide, TSM 3-4 & 1-2 C 75M07371 Bracket, Assembly, Lines Support, TSM #1-2 D 75M08659 Bracket, Assy, 2" Lines, TSM #1-2 D 75M07384 Casting, Cable Clamp Collar TSM D 75M07374 Clamp Assembly, 10" Line, TSM #3-2 C 75M09405 Clamp, Casting & Machining TSM 3-4 & 1-2 C 75M07523 Clamp, 2" Pipe, TSM #1-2 B 75M09414 Clamp, 2 1/2" Pipe, TSM #1-2 B 75M09415 Collar, Cable Clamp, TSM #1-2 D 75M07379 Collar, Cable Clamp, TSM #3-2 D 75M08648 Collar, Cable Clamp TSM 3-4 D 75MO7373 Detail, Interface Plate, TSM #1-2 J 75M09410 Detail, Interface Plate, TSM #3-2 J 75M08653 Duct Assembly, 10" Line, TSM #3-2 D 75M08656 Flange, 2" Line, TSM #1-2 C 75MO9532 Flange, 6" Line, TSM D 75M10226 Flex Hose Assy, LOX TSM 3-4 D 75M07381 Flex Hose Assembly, 6" RP-1, TSM #1-2 D 75M09407 Gasket, 2" Line, TSM #1-2 C 75M09531 Gasket, TSM 3-4 & 1-2 C 75M07516 Guide 6" Line TSM 3-4 & 1-2 C 75M07372 Guide, Pipe Alignment, TSM 1-2 & 3-4 D 75M07360 Hose Assembly, Metal Flexible, TSM #1-2 B 75M07947 Hose Assy, Flexible, TSM #1-2 D 75M09679 Hose Assembly, TSM #1-2 D 75M09413 Hose Assembly, TSM #3-2 D 75M08652 Hose Assembly, TSM 3-4 D 75M07376 Hose Assy, Purge TSM C 75M11929 Interface Plate, Assembly TSM 3-4 J 75M07363 Interface Plate, Detail, TSM 3-4 J 75M07362 Plate, Front Bulkhead, TSM 3-4 & 1-2 C 75MO7365 Plate, Rear Bulkhead, TSM, #1-2 D 75M08661 Plate, Support, 6" Line TSM 3-4 & 1-2 C 75M07364 Plate, Tee, Front Bulkhead, TSM #1-2 D 75M08660 Service Lines Installation TSM #1-2 J 75M06803 Service Lines Installation, TSM 3-4 J 75M06652

10-4 SERVICE LINES (Continued)

```
J 75M06804 Service Lines Installation, TSM #3-2
C 75MO9533
            Split Ring, TSM #1-2
            Support #1, TSM #3-2
C 75M08649
D 75M08657
            Support, 10" Line, TSM #3-2
C 75M07366
            Support No. 1 TSM 3-4
D 75M08650
           Support #2, TSM #3-2
D 75M07367
            Support No. 2 TSM 3-4
D 75M07368
            Support No. 3 TSM 3-4
D 75M07369
            Support No. 4 TSM 3-4
C 75M07370
            Support No. 5 TSM 3-4
D 75M07382
           Tube Assy, Lox TSM 3-4
D 75M09406
            Tube Assembly, 6" RP-1, TSM #1-2
C 75M11928
           Tubing Assy Purge, TSM
D 75M09412
           Tubing Assembly, TSM #1-2
D 75MO7375 Tubing Assembly, TSM 3-4
D 75MO8651 Tubing Assembly, TSM #3-2
           Union, Bulkhead, Special, TSM #1-2
D 75M09408
D 75M07377
           Union Bulkhead, Special TSM 3-4
D 75M09404 Union, Bulkhead Special, TSM #3-2
B 75M07656
           Valve Ball Shut-off, 6" Line, Lox Service, Norm. Open, TSM #3-4
B 75M07656
           Valve, Ball Shut-off, 6" Line, RP-1 Service Norm. Open TSM #1-2
```

10-5 HANDLING EQUIPMENT

B 75M09610 Valve, 3/8" Check, TSM #1-2

J 75M06682 Beam, Lifting TSM J 75M10463 Handling Equipment Kit and Installation Procedure, TSM J 75M06672 Handling Frame Assy., TSM D 75M10401 Key-Hold Plate, TSM C 75M10362 Spacer, Scr. Pin Shackle, TSM D 75M12050 Two-Leg Wire Rope Sling Assy, TSM D 75M10361 Wire Rope Assy, TSM D 75M10360 Wire Rope Bridle Sling Assy TSM D 75M10466 Wire Rope Sling Assy, TSM

10-6 HYDRAULICS

```
Accumulator, 1155 Cu. in., Hydraulic, TSM
B 75M07653
           Accumulator, 1304 Cu. In., Pneumatic, TSM
B 75M07640
           Adapter Assy., 1 1/2" Coupling, TSM
B 75M09261
            Bracket, Cam Valve, TSM
D 75M07515
           Bracket, Coupling, TSM
в 75м09259
            Bracket, Valve, TSM
B 75M07405
           Bracket, Valve, TSM
B 75M07406
           Bracket, Valve, TSM
B 75M07410
            Bracket, Valve, TSM
C 75M07415
            Bracket, Valve, TSM
C 75M07417
            Bracket, Valve, TSM
в 75М07519
            Bracket, Valve, TSM
C 75M07520
            Bracket Valve, TSM
C 75M07672
            Bracket Valve, TSM
C 75M07740
            Cam. TSM
D 75M07670
            Cam Support, TSM
D 75M09258
            Check, 1/4", Pneumatic, TSM
B 75M07652
            Clamp, TSM
C 75M07518
            Clevis, Bracket, TSM
D 75M09817
            Connector, TSM
B 75M07674
            Connector 1 1/2", Bulkhead, TSM
B 75M07396
            Cylinder, Hydraulic, TSM
B 75M07639
            Cylinder Assy, Hydraulic, TSM
D 75M07615
            Elbow 45° BLK, TSM
B 75M07669
            Eye Bracket, TSM
D 75M09819
            Filter, 3/8", Bydraulic, TSM
B 75M07636
            Filter, 1/4", Pneumatic, TSM
B 75M07620
            Flexable Hose Assy, Base TSM
D 75M07737
            Gauge, Pressure 0-5000 PSI, TSM
B 75M07634
            Hyd. & Pneu Installation, Base, TSM
J 75M07139
            Hyd-Pneu Tubing Assy, Base, TSM
J 75M06631
            Hydraulic - Pneumatic Schematic Base, TSM
J 75M)7676
            Name Plate, Schematic, TSM
F 75M09260
            Orifice, Hydraulic, TSM
B 75M07648
            Panel Valve, TSM
D 75M07418
            Pin, Cylinder, TSM
C 75M09818
            Reducer, 1/4", Hydraulic Pressure, TSM
в 75М07629
            Regulator, Pressure Reducing, TSM
B 75M07647
            Regulator, Pressure Reducing 0-3100, TSM
B 75M07650
            Return Check Valve, TSM
B 75M11879
            Rod Eye, TSM
C 75M07616
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10-6 HYDRAULICS (Continued)

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Shim Cam Valve, TSM
C 75M07514
            Spacer, TSM
B 75M07671
            Support, Clip, TSM
B 75M07403
            Support Clip, TSM
в 75М07407
            Support, Clip, TSM
B 75M07408
            Support, Clip, TSM
в 75м07409
            Support, Clip, TSM
C 75M07416
            Support Clip, TSM
B 75M07673
            Support Clip, TSM
C 75M07705
            Support, Clip, TSM
B 75M07414
            Support, Grommet, TSM
B 75M07412
            Switch, Pressure, TSM
B 75M07638
            Tee 1/4", TSM
в 75м07397
            Tee 1/4" Bulkhead, TSM
B75M07398
            Tee, Reducer, TSM
в 75м07399
            Tee, Reducer, TSM
B 75M07400
            Tee, Reducer, TSM
B 75M07401
            Tee, Reducer, TSM
B 75M07402
            Tee, 3/4 Bulkhead, TSM
B 75M07411
            Tee, 3/4 Bulkhead, TSM
B 75M07413
            Tee 3/8" TSM
B 75M07717
            Tee Reducer, TSM
B 75M07718
            Tee Reducer, TSM
B 75M07742
            Tee, 1/2" TSM
B 75M07703
            Transducer, TSM
B 75M07649
            Union Bulkhead, TSM
B75M07741
            Valve, Ball Shut-off, 3/8" Solenoid Opr., Norm. Closed, TSM
B 75M07655
            Valve, 3/8" Check, TSM
B 75M07654
            Valve, 1/4" Solenoid Opr., Norm. Closed, TSM
B 75M07651
            Valve, Ball-Shut off, 1 1/2", CAM Opr., Norm. Open, TSM
B 75M07646
            Valve, Ball Shut-off, 1 1/2", Pneu. Opr., Norm. Open, TSM
B 75M07645
            Valve, Ball Shut-off, 1 1/2" Solenoid Pilot, Pneu. Opr., Norm.
B 75M07644
             Closed, TSM
            Valve, Ball Shut-off, 1 1/2", Pneumatic Opr. Norm. Closed, TSM
B 75M07643
            Valve, Ball Shut-off, 3/8", 4 way, 2 position, Sol. Pilot, Pneu.
B 75M07642
             Opr., Norm. Closed, TSM
             Valve, Ball Shut-off, 1 1/4", Solenoid Pilot, Opr. Norm.
B 75M07641
             Closed, TSM
             Valve, 1/4", Solenoid Opr., Norm. Open, TSM
B 75M07637
            Valve, 1/4", 3 way, 2 position Solenoid Opr., Norm. Open, TSM
B 75M07633
             Valve, 1/4", Hydraulic Bleed, TSM
B 75MO7631
            Valve, 1/4", Manual Opr., TSM
 в 75М07630
B 75M07621 Valve, 1/4" Flow Restrictor, Manually Adjustable, TSM
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10-7 ELECTRICAL

A 75M08644 Acceptance Checkout Procedure, TSM A 75M08071 Acceptance Checkout Procedure, TSM D 75M07525 Advanced Schematic, TSM C 75M07524 Bracket, Connector Mounting, TSM D 75M09060 Cable Assy, TSM 1-2 D 75M09061 Cable Assy, TSM 3-2 D 75M09062 Cable Assy, TSM 3-4 F 75M08316 Electrical Distributor, TSM 1-2 F 75M08315 Electrical Distributor, TSM 3-2 F 75M07735 Electrical Distributor, TSM 3-4 J 75M07528 Electrical Installation, TSM 1-2 Electrical Installation, TSM 3-2 J 75M07527 J 75M07529 Electrical Installation, TSM 3-4 F 75M07660 Face Panel, Silk Screening, TSM F 75M07659 Face Panel, Universal Test Set, TSM D 75M07701 Interconnection Diagram, TSM 1-2 D 75M07702 Interconnection Diagram, TSM 3-2 D 75M07700 Interconnection Diagram, TSM 3-4 A 75M11567 Operational Checkout, TSM A 75M07667 Patching List, Test Set 7601 TSM B 75M09464 Spacer, Retract Reel, TSM E 75M07658 Test Set, TSM A: 75M07668 Wire Running List, Distributor, TSM